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Heads Win

The other day on a street corner, I saw two little newsboys matching pennies. As I passed, one of them shouted, "Heads win!"

That little ragged urchin did not realize that he was proclaiming a great truth. But he was.

Time was when money was looked upon as being the chief factor in every branch of life. The capitalist was looked at with envy, and sometimes with fear. That day is fast passing away. People know differently now. It is headwork that wins today.

In the great world war it was not the money, the men, the tremendous amount of ammunition, the submarines, which won. It was brains. If the enemy produced a deadly gas, then the brains of the opposing forces were set to work to produce a gas more deadly than the other. When the submarines began to take their daily toll of ships sunk and destroyed, the allied nations realized that they must think out a way to get rid of these reptiles of the sea. And they did it. The magnificent brain of Foch and his generals planned a campaign which wore down the German hosts and in the end accomplished their defeat. Brains did it, not guns. Heads won.

In the industrial world it is not the man with the biggest muscles that gets to the top. It is not the man with massive arms and iron hands, who can lift a hundred-pound weight with ease, who gets the most money in the pay envelope at the end of the week.

It is the man whose brain is active, who thinks and plans and studies the best way to do a job. It is the man of power. And power does not mean brute force. Power comes from constructive thinking, cumulative thought or, in the parlance of the street, "using your head."

Some weeks ago a Foreword appeared in *Power* on "The Passing of the Boss," which was full of common sense and truth.

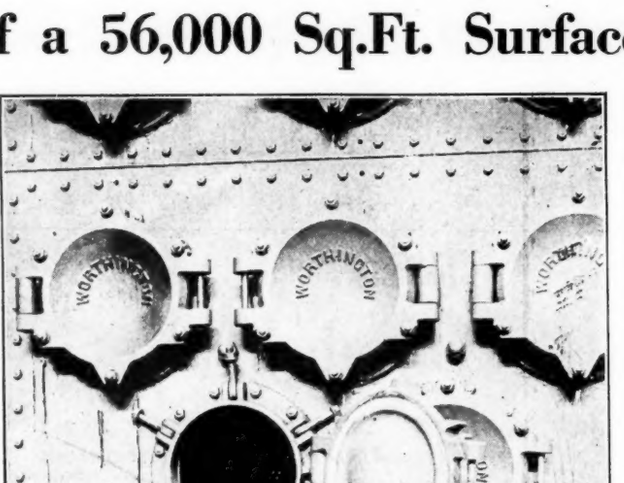
Why is the "boss" passing? Because men are beginning to think for themselves. The day when they were driven or led to do things by soft words and unctuous phrases has gone by. Today men in all branches of industry are fast thinking out their problems without help from others. They are using their heads and they glory in it. Just in proportion as they learn to think for themselves will men grow in power to do and live and prosper.

The next time you hear a man grumble over the amount he gets in his pay envelope, tell him the story of the newsboy who unwittingly emphasized the great truth, "HEADS WIN."

Contributed by FRANK DORRANCE HOPLEY.

Particulars of a 56,000 Sq.Ft. Surface Condenser

WHILE not the largest surface condenser built, the one described herewith has, in common with other large ones constructed for recent installations, many features of interest. It is of the Worthington type and has a total of 56,000 sq.ft. of tube surface, including that for the heater; there are 54,500 sq.ft. of condensing surface and 1500 sq.ft. for the heater. The tubes and tube plates are of Muntz metal, the condenser going into service in one of the large power stations of the Middle West, for the circulating waters of which this metal is well suited. The condenser will serve a 35,000-kw. turbine and will be placed in rather crowded quarters. This accounts for the short shell, which is but 15 ft. 3 in. long by 21 ft. 9 in. in diameter inside, 23 ft. outside flange diameter. The tube heads are 18 ft. 8 in. in diameter by 1½ in. thick. There are 14,280 one-inch tubes, 15 ft. 6¼ in. long, 384 of which are in the heater. Empty, the condenser weighs 700,000 lb., and it will contain 130,000 lb. of water, giving a total weight of 830,000 lb. The castings for the shell of such a condenser, unlike structural castings of like size, must be watertight; there must be no spongy spots. The foundry where these castings were made—that is, at the Harrison, N. J., works of the builder — is particularly proud of them because they not only look pleasing but are sound everywhere, and these were the only castings made for this condenser. The circulating pump is a 48-in. double-suction volute of 60,000



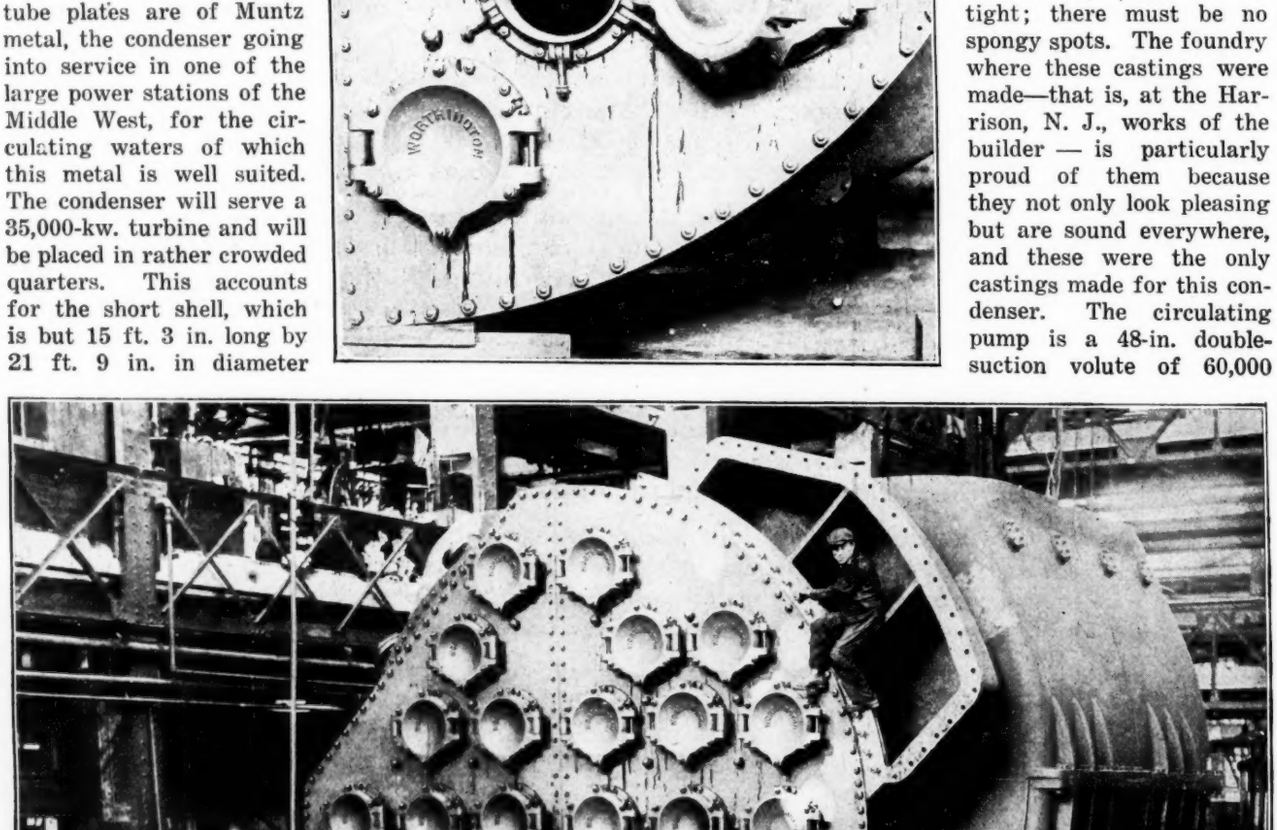


FIG. 1, BELOW. A 56,000-SQ.FT. SURFACE CONDENSER FOR A 35,000-KW. SINGLE-SHAFT TURBINE. FIG. 2, ABOVE. TYPE OF DOOR FOR WATERBOXES.

gal. per min. at 20 ft. head and 300 r.p.m. The suction is 54 in. in diameter, with 48-in. delivery. It will be driven by a 435-hp. 25-cycle three-phase 220-volt G. E. motor. Three No. 10 hydraulic vacuum pumps, arranged for use of one, two or three units, are provided. Two combined units, driven by Westinghouse turbines, will handle the condensate and vacuum pump water. Each of these units has a 10-in. split-casing single-stage double-suction pump delivering water to the hydraulic vacuum pumps, and a 6-in. split-casing two-stage condensate pump. These pumps and the turbine are all mounted on the same bedplate. Each turbine is of 166 hp. capacity. A feature of the condenser is the type of door used in the shell heads and shown in Fig. 2. This door is concave, giving considerable strength for comparatively small thickness in the concave area, yet providing a heavy rim to contain the canvas-rubber gaskets. The door may be attached so as to swing either right or left. Each nut on the swinging studs has a washer cast integral with it. Of course the station crews readily appreciate the convenience of this feature. The condenser is supported on duplex coil springs—the 8-in. outside diameter, 1½-in. section spring having a 4⅞-in. outside diameter, 1 5/16-in. section spring inside it, as shown in Fig. 4. The large springs are 7¾ in. long when uncompressed and 6 in. when compressed. Beneath each spring guide-pin (cast steel) is a 10-in. jackscrew, 3½ in. outside diameter, 6 threads per inch. Each jackscrew engages 4 in. of threads or 24 threads in the spring support, each one of which is 4 ft. 8 in. long by 2 ft. 11 in. wide, of cast iron.

The area of the exhaust opening into the condenser is roughly 133 sq.ft. The free exhaust opening in the shell is 42 in. in diameter; the air-pump suction opening is 20 in.; the circulating-water opening is 30 x 84 in. Both inlet and outlet to the heater are 10 in. diameter; the makeup-water connection is 6 in. in diameter. There also is an 8-in. makeup connection into the bottom of the circulating-water connection for hydraulic vacuum pump hurling water makeup. Through this connection water will be supplied for keeping down the temperature of the hurling water to the hydraulic vacuum pumps, so the water may be kept at a temperature but little higher than that passing the circulating-water inlet. The hot-water suction opening in the hotwell is 12 in. A 3-in. pipe tap is made in the ring-head end to connect with a 3-in. oil-cooler outlet. The oil-cooler overflow, at the top and opposite end of the condenser, is 6 in. diameter. At the top of the ring-head end there is a 3-in. priming connection.

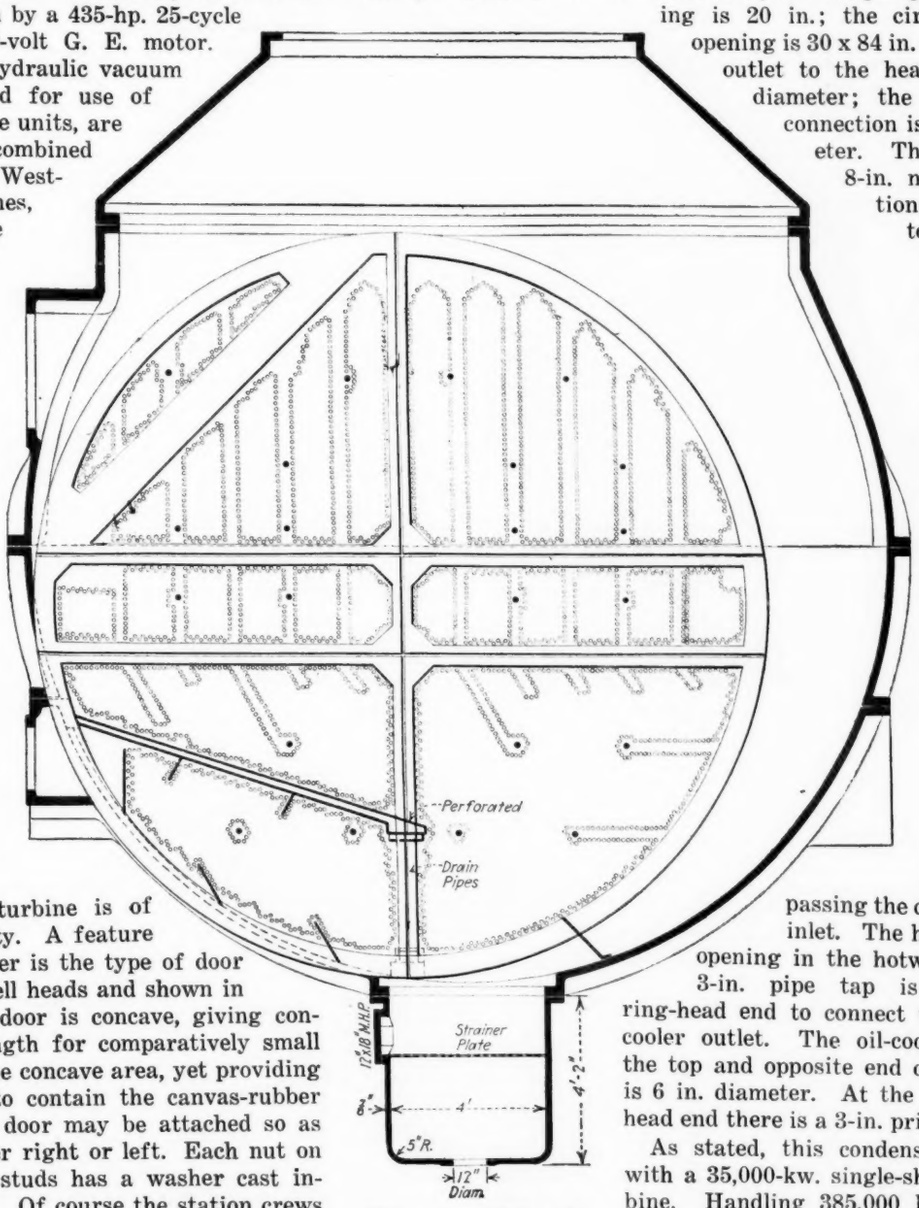


FIG. 3. TUBE ARRANGEMENT, BAFFLES AND HEATER TUBES

As stated, this condenser will be used with a 35,000-kw. single-shaft impulse turbine. Handling 385,000 lb. of steam per hour, the vacuum maintained with circulating water at 70 deg. F. will be 28.4 in. mercury with 60,000 gal. per min. circulating. With 45-deg. circulating water, other conditions the same, a vacuum of 29 in. mercury will be maintained.

There follow some chief data concerning, the condenser, Fig. 3, shows able for inserting in one's notebook.

The diagram of the condenser, Fig. 3, shows clearly the arrangement of tubes to provide steam lanes. The writer believes that in this large condenser a greater number of these lanes are provided than is customary with large condensers. The lower tubes become more effective.

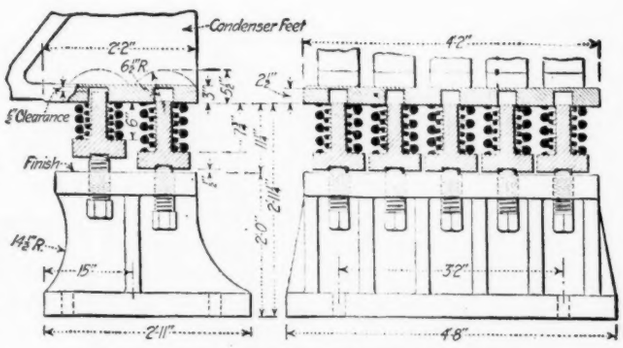


FIG. 4. CONDENSER-SUPPORTING SPRINGS

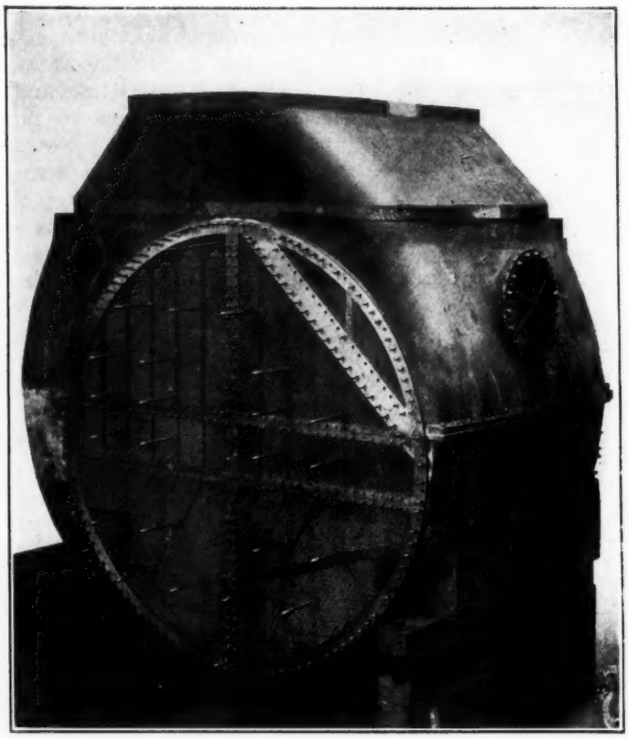


FIG. 5. THE CONDENSER WITH WATER BOXES REMOVED

DATA ON WORTHINGTON CONDENSER FOR 35,000-KW. SINGLE-SHAFT TURBINE

Length of shell	23 ft
Diameter, inside	21 ft. 9 in
Material of tubes and tube heads	Muntz metal
Total tube area, sq.ft	56,000
Condensing area, sq.ft	54,500
Heater area, sq.ft	1,500
Tubes, 1 in. diameter, 18 gage B.w.g	
Weight condenser, empty, lb	700,000
Weight condenser with water, lb	830,000
Weight condenser with water per rated kw. of turbine, lb	23.8
Tube area per rated kw. capacity of turbine, sq.ft	1.6
Tube area of heater per rated kw. capacity of turbine, sq.ft	0.043
Condensing tube area per sq.ft. heater-tube area, sq.ft	36.2
Water circulated per lb. steam condensed at rating, lb	78
Circulating-water pumping capacity per rated kw. turbine capacity, gal. per min	1.43
Heat transmission per sq.ft. tube area per deg. difference inside and outside of tube, B.t.u. per hr. (estimated)	400 to 420
Circulating-water pumping capacity per sq.ft. total tube area, gal. per min	1.07
Condensate pumping capacity, gal. per min., maximum	1,200
Condenser support	Duplex helical springs

Surface Condensing Plant Temperatures

BY MARK MEREDITH

When tuning up surface condensing plants, it is highly desirable that, having a good vacuum, the hotwell-water temperature should be kept as high as possible consistent with that vacuum, and a little trouble taken to regulate the cooling-water supply to suit the load on the condensing plant will be amply repaid.

There should not be more than 10 deg. F. difference between the hotwell-water temperature and the theoretical temperature:

Vacuum, In.	Theoretical Temperature, Deg. F.
20	161.28
21	156.83
22	151.97
23	146.55
24	140.42
25	133.32
26	124.89
27	114.34
28	100.05

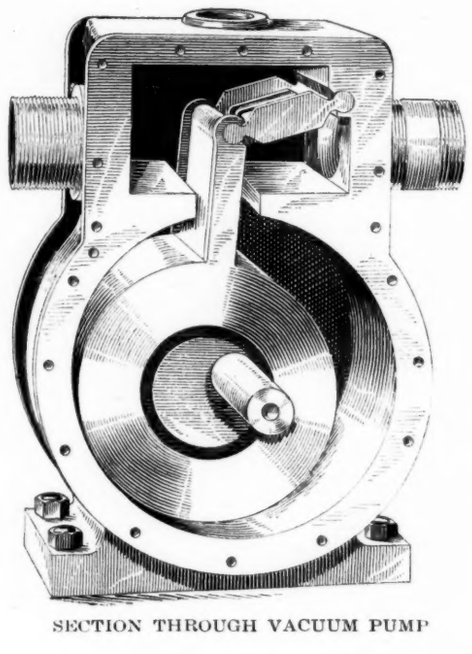
A difference of more than 10 deg. F. indicates either air leaks in exhaust main, inefficient air pump, or if vacuum is high too much cooling water passing. There should not be more than 15 deg. to 30 deg. F. difference between hotwell temperature and the cooling-water discharge temperature. A high difference indicates either an excess of cooling water or a dirty condenser. The former is shown by low hotwell temperature, the latter and more usual by high hotwell temperature. A low vacuum with a high temperature in both hotwell and circulating-water discharge shows that insufficient circulating water is passing and may be due to the centrifugal pump running at wrong speed or to its impeller being worn.

It should also be remembered that, although steam turbines require as high a vacuum as can be obtained, to achieve the best results as regards coal consumption, reciprocating engines generally give their best results with about 25.5 to 26 in. vacuum, the hotwell temperature being kept as near as possible to the theoretical temperature.

Thompson Return-Line Vacuum Pump

In a vacuum heating system the condensation from the radiators, together with the air, is drawn by suction to a pump, where the air is separated from the water, and the hot water is returned to the boiler or to a receiver. Naturally, a vacuum pump should be simple in construction, quiet in operation and durable.

The illustration shows a pump that has but three moving members, the crank and the impeller, and a



SECTION THROUGH VACUUM PUMP

hinged plate, the purpose of which is to separate the suction and the discharge side of the pump cylinder. The surfaces of the impeller and the pump casing are cylindrical, and the impeller is at no time in contact with the casing, a very close clearance being maintained. The crankshaft of the impeller is fitted with ball bearings, and as the crank turns in a clockwise direction, it gives the impeller an eccentric motion. As the water enters the inlet pipe it discharges into the space between the rotor and the casing, and as the rotor revolves this water is carried around until it escapes through the discharge pipe. This pump is being manufactured by the Thompson Manufacturing Co. of Des Moines, Iowa.

Characteristics of Illinois Coal and How To Burn It

By T. A. MARSH
Chief Engineer, Green Engineering Co., East Chicago, Ind.

Coals of Illinois by the bed and the district. Relative values as steaming coals, their characteristics and analyses. Types of furnaces best adapted to burning these coals smokelessly and at high efficiency on the chain grate.

DURING the year 1918 Illinois produced over 88 million tons of coal, ranking as third state in coal production. All this coal is bituminous, or in nontechnical terms, smoky, free-burning, "clinkery" coal, having ash that fuses at a relatively low temperature. There are five definite producing coal beds in

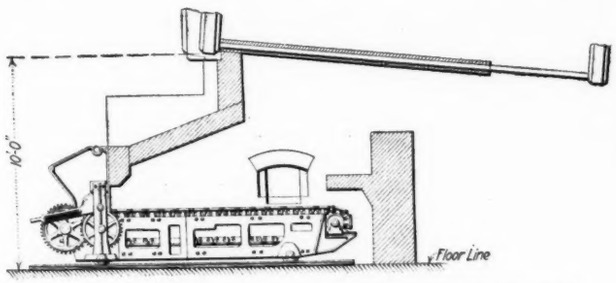


FIG. 1. TYPICAL FURNACE FOR HORIZONTALLY BAFFLED BOILER

the state, but a discussion of Illinois coal becomes more simple when it is learned that 90 per cent. of all coal produced comes from two beds, and but little consideration need be given to the others.

Knowledge of the bed alone is not an exact criterion of the quality of coal. However, the quality produced from any bed in a given district is fairly uniform, so that a knowledge of the district and the bed identifies a coal. On this basis there are nine coals to consider in Illinois. A tabulation of these coals with typical analyses of their screenings, including the fusion temperatures of the ash, is given in Table I. These analyses being based on screenings, contain approximately 2 to 4 per cent. more ash than mine-run samples and 3 to 6 per cent. more than lump samples. It is attempted in these analyses to represent the average of the seam in the districts. Many mines, therefore, in large districts produce better coal. For instance, in the Herrin district, mines in some localities give screenings from No. 6 coal with less than 10 per cent. ash and 1 per cent. sulphur.

Coal from No. 1 bed is mined most extensively in the Rock Island district, although in Christian County some is mined which contains approximately 2 per cent. less sulphur than that of the Rock Island district.

Coal from No. 2 bed is mined in two districts, La Salle and Murphysboro. As produced at La Salle, screenings are high in ash and sulphur, as the seam is thin. Most steam producers in the district consider this coal uncommercial. Notwithstanding, it can be burned in furnaces of proper design and is now giving satisfaction up to 200 per cent. of rating in furnaces of the type shown in Fig. 3.

As regards ash and sulphur content Murphysboro No. 2 is the purest coal produced in Illinois. Lump samples frequently contain 14,000 B.t.u. on the dry basis, an exceptionally high figure for Illinois coal. The excellent quality of this coal practically eliminates it from the steaming-coal market, as it is in high demand for domestic and other purposes.

No. 5 coal is produced in the Harrisburg and the Springfield districts. Of these the former is by far the better coal, its high heat value and the relatively high fusion point of the ash making it a desirable fuel for those plants having limited boiler capacity. Springfield, or Central District No. 5, coal has a softer structure than that from the Harrisburg district. Its high ash and sulphur contents, lower fusion temperature of the ash and lower heat value make the use of this coal prohibitive in many steam plants. It is unsuitable for stokers not having a continuous ash discharge from the furnace, as it tends to clinker badly if the fuel bed is agitated.

Either the Harrisburg or the Springfield No. 5 coal is excellent chain-grate fuel. When designing a stoker for Springfield coal, it is customary to allow more liberal grate area and to provide longer ignition arches than for Harrisburg No. 5. In some localities, however, the Harrisburg coal becomes more expensive per 1000 lb. of steam, as, owing to its superior qualities, it commands a higher price than Springfield coal.

No. 5 coal is produced also in the Peoria district, but its heat value is so low, because of the high ash content, that comparatively little of it is used in steam plants and much coal for the Peoria market is imported from the Springfield district. This is an economical loss, as it is possible to obtain good efficiencies and capacities with the Peoria coal provided furnaces are designed properly.

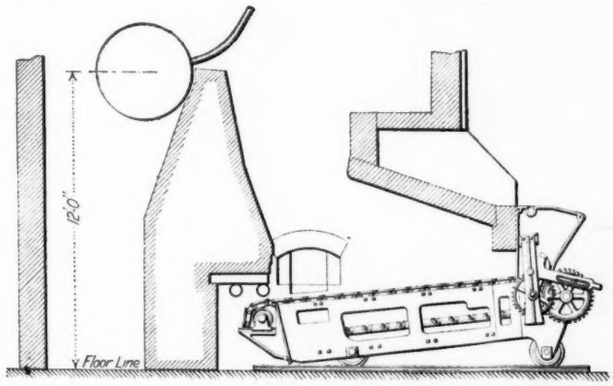


FIG. 2. DESIRABLE FURNACE FOR STIRLING BOILER

Coal from bed No. 6 of Illinois also has a wide range in quality and characteristics according to the locality in which it is mined. The coals of the Bellville district have limited utility and low heat value, while the Franklin county No. 6 coal is an excellent fuel.

The coals of the Herrin district have become more widely known than any other Illinois coals, due to their comparatively low ash and sulphur contents and their relatively high ash-fushion point. Clinker trouble may be reduced by the use of these coals, but plants limited to these fuels, either due to inadequate boiler capacity

or grate area or to clinker trouble, have to contend with high steam costs, as the price of coal is higher than would exist if the entire coal market were open to them.

No. 6 coal produced in the Bellville district is high in ash and sulphur and has a low fusing point. It forms a plastic, sticky clinker, difficult to handle when once formed. Coals from this district are known in St. Louis as the "inner group." The relatively low heat value and long haul prohibit marketing these coals in Chicago except under abnormal market conditions.

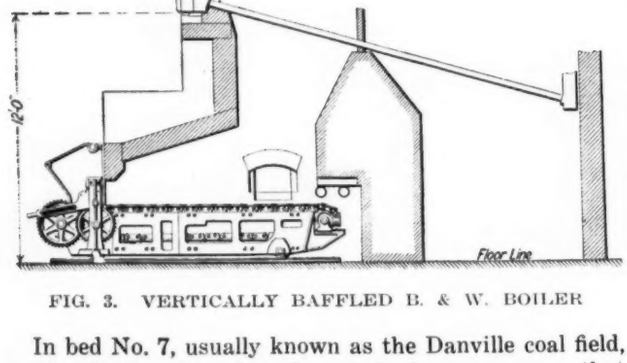


FIG. 3. VERTICALLY BAFFLED B. & W. BOILER

In bed No. 7, usually known as the Danville coal field, production has been largely a stripping process, so that the coal is high in ash. The sulphur content also is high.

In general, from a combustion standpoint, Illinois screenings may be described as smoky, clinkery, high-ash coals of about medium heat value as compared with the best and the poorest coals in the country. Yet in spite of their abnormal characteristics, Illinois coals are being burned without producing smoke and are being handled with a greater freedom from clinker than is normal in Eastern plants with the highest-grade fuels. In spite of the high percentage of ash fires are kept clean, and notwithstanding the low heat value boilers are operated at from 200 to 250 per cent. of rating, which is in accord with good, modern practice.

These facts emphasize the progress of combustion engineering. It has been necessary to burn these coals

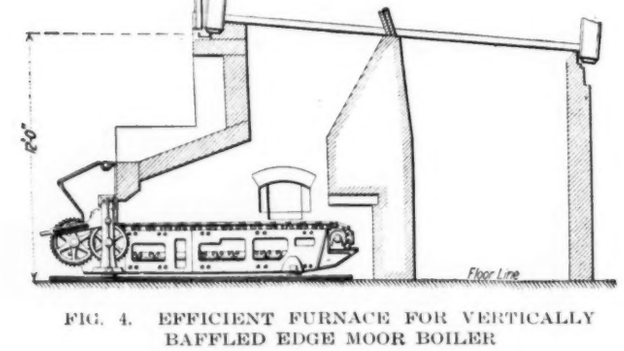


FIG. 4. EFFICIENT FURNACE FOR VERTICALLY BAFFLED EDGE MOOR BOILER

and without smoke in many districts. Clinker trouble was serious with hand firing and with stokers designed for Eastern coals, so that stokers had to be developed to eliminate this trouble and also to remove the high percentage of ash carried by this coal. The chain grate has been found suitable to meet these conditions.

Efficiencies during the development period were not high; 65 to 68 per cent. was considered good practice. It was largely a question of furnace design. Improved furnaces permitting complete combustion of the hydrocarbons, of which there is such a large percentage in Illinois coals, have increased the efficiency until 72 to 75 per cent. is as commonly obtained now as the lower range ten years ago.

Table II gives some chain-grate performances with Illinois coals, indicating the results that are obtainable. It will be noticed that in test No. 2 a combustion rate of 48.21 lb. of coal per square foot of grate area per hour over a period of four hours, while developing 244 per cent. of rating continuously, was maintained. Higher ratings were carried for short intervals, and peaks of steam output could be carried in excess of this rating.

To produce cheap power, it should be possible to burn all coals available to the market in which the plant is located. The necessity of picking certain coals or of importing coals from a remote district is usually an expensive necessity. In many instances existing plants are unable to burn all coals in the market. The selection of stokers, their proportions and the furnace design should take into consideration the quality of coal to be utilized in the locality, making it unnecessary to select certain better fuels in order to get satisfactory operation.

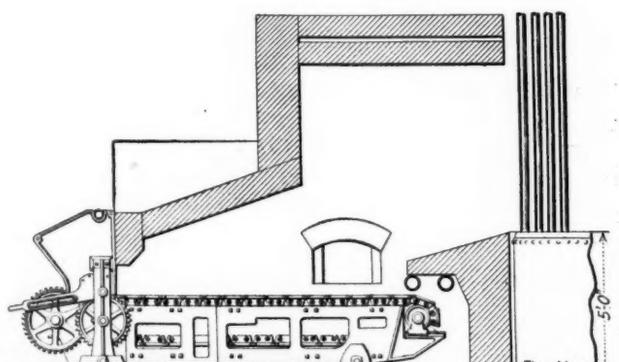


FIG. 5. FURNACE FOR VERTICAL BOILER

Some typical furnaces of desirable proportions for Illinois coals are shown in the accompanying drawings. All boilers are shown set at heights to give large furnaces.

Fig. 1 indicates a horizontal baffled boiler with a typical furnace for Illinois coals. Even in the early stages of the art of smokeless combustion this furnace was known to be smokeproof up to high overloads. The ample proportions of furnaces as installed today render this furnace smokeless up to and even beyond 250 per cent. rating of the boiler. Fig. 2 shows a Stirling boiler with a desirable furnace for Illinois coals. Figs. 3 and 4 show furnaces for vertical baffled boilers. These furnaces have the same smokeless characteristics as the design shown in Fig. 1. The furnace shown in Fig. 5 is used with vertical boilers. These boilers lend themselves readily to full dutch-oven furnaces that make complete combustion and smokelessness easy to obtain.

In all these designs the arch lengths and grate areas are dependent on the coal to be used. The furnaces shown are more liberally designed than those required for smokelessness and therefore will operate at better efficiencies than would be the case if minimum dimensions for smokeless operations were used. It is now known to be common practice with chain grates to obtain 70 per cent. efficiency and upward without smoke when operating at 200 per cent. of rating.

The important points to remember in connection with this consideration of the combustion of Illinois coals are:

1. The coal produced from any of the Illinois seams in the southern part of the state is better than that produced from the same seams in the northern part.

2. Of all coal produced in Illinois, 90 per cent. comes from seams Nos. 5 and 6.

3. Coal is frequently imported into an actual producing district where it is burned in preference to the local product. Such districts are notably La Salle, Peoria and Belleville. This is an economic waste and should be corrected by the installation of suitable furnaces for burning the local coal.

4. Even the poorest coals of the state are being burned at 200 per cent. of rating and beyond with good efficiencies.

5. Chain grates are particularly well adapted for all Illinois coals, owing to the absence of clinker troubles.

6. Smokelessness with chain grates using Illinois coals can be assured.

7. Higher efficiencies are being obtained by using furnaces more ample than the minimum requirements for smokelessness.

TABLE I. TYPICAL ANALYSES OF ILLINOIS SCREENINGS BY DISTRICTS AND BEDS

Coal by District and Bed	Moisture	Volatile	Fixed Carbon	Ash	Sulphur *	B.t.u. Commercial	B.t.u. Dry Basis	Fusion Temp. of Ash
District No. 1..... La Salle Co. No. 2 coal	11.92	33.28	34.64	20.16	4.50	9,509	10,796	2,025
District No. 2..... Jackson Co. No. 2 coal	9.28	31.97	49.00	9.75	1.29	11,975	13,199	2,425
District No. 3..... Rock Is. and Mercer Co. No. 1 coal	13.46	34.5	34.54	17.5	4.8	9,808	11,334	2,050
District No. 4..... Springfield Nos. 5 and 6..... Peoria No. 5 coal	13.00	34.8	37.00	15.2	4.5	10,353	11,900	2,179
District No. 5..... Harrisburg No. 5 coal	12.2	33.2	35.00	19.6	4.00	9,719	11,070	....
District No. 6..... Herrin No. 6 coal	6.75	33.49	46.72	13.04	3.00	11,493	12,325	2,291
District No. 7..... Belleville No. 6 coal	8.00	33.00	45.5	13.5	2.25	11,362	12,350	2,350
District No. 8-a.... Grape Creek No. 6 coal	12.56	34.00	34.44	19.00	4.80	9,813	11,222	2,091
District No. 8-b.... Danville No. 7 coal	14.45	36.55	36.00	13.00	2.55	10,500	12,274	2,175
	12.99	35.55	35.0	16.46	2.93	10,070	11,575	2,125

* Separate determination.

TABLE II. CHAIN-GRATE PERFORMANCE WITH ILLINOIS COALS

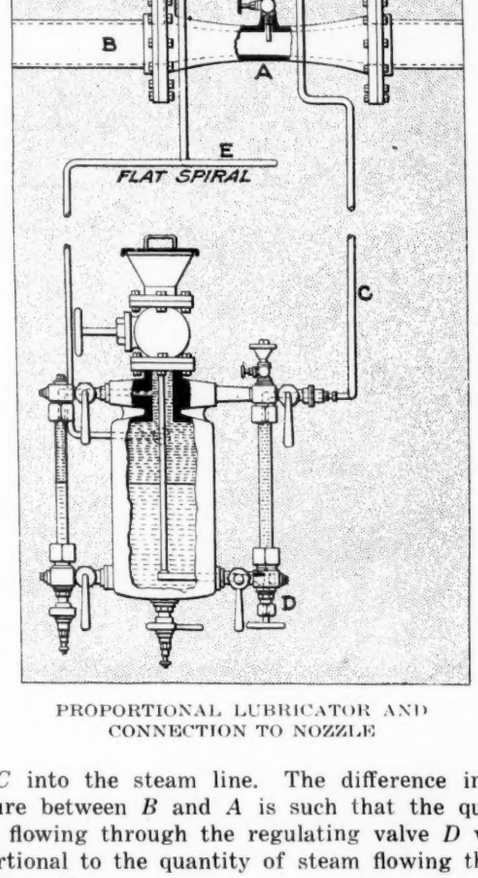
Test No.	1	2
Type of boiler	Stirling	Edge Moor
Type of grate	Green-type K	Green-type K
Area of grate, 29-ft	99	100
Ratio of grate area to heating surface	50.66	52.8
Duration of test, hours	8	4
Horsepower rating of boiler	501	528
Name of fuel	Harrisburg No. 5	Franklin No. 6
Size of fuel	1½ in. screenings	Screenings
Moisture, per cent	9.5	5.6
Volatile, per cent	30.01	26
Fixed carbon, per cent	50.94	53.6
Ash, per cent	11.35	12.1
Sulphur, per cent	3.79	
B.t.u., commercial	12,000	11,572
B.t.u., dry basis	13,270	12,250
Furnace draft, in.	0.34	0.58
Uptake draft, in.	0.73	1.37
Coal per square foot of grate area per hour, lb.	31.4	48.21
Per cent. rating developed	164	244
Combined efficiency, per cent	74.74	71.25

Business secrets used to be considered a large part of the stock in trade, to be jealously guarded from all competitors. More recently it has become evident that such secrets were of but small value, in no way comparable to the profits to be obtained from the application of new ideas worked out by one individual to the trade as a whole.

Meyeringh Proportional Lubricator

The ordinary hydrostatic lubricator, the regulating valve once set, supplies the steam in the line to which it is connected with the same amount of oil independent of the number of revolutions of the pump or engine by which the steam is consumed, thereby providing lubrication that is not always in proportion to the load.

With the proportional lubricator, as shown in the illustration, the quantity of oil fed to the steam line is automatically kept proportional to the quantity of steam flowing through the line. It comprises an oil reservoir, a condensation pipe formed as a flat spiral and a nozzle interconnected as indicated. As the velocity of the steam flowing through the nozzle is higher in the contracted part *A* than in the full diameter *B*, the gage pressure will be higher at *B* than that at *A*, thus forcing oil from the lubricator through the oil



PROPORTIONAL LUBRICATOR AND CONNECTION TO NOZZLE

pipe *C* into the steam line. The difference in gage pressure between *B* and *A* is such that the quantity of oil flowing through the regulating valve *D* will be proportional to the quantity of steam flowing through the steam line.

The condensation spiral *E* is so proportioned that all steam entering this line is condensed. Above the spiral the small line is filled with steam, and when the latter part is well insulated, no condensation will take place in it. By this device the hydrostatic action on which the hydrostatic lubricator is based is eliminated and only such forces work in the oil receptacle as give proportional lubrication. The advantage of the device is that it can be installed in a main steam line feeding one or more pumps and engines at the same time.

The proportional lubricator is put out by the Oil Well Supply Co., Pittsburgh, Penn.

Reverse-Current Relays—Principles of Operation

By VICTOR H. TODD

ONE of the problems confronting the users of direct-current apparatus is how to protect a circuit or piece of apparatus from damage due to reversal of current or power. For example, a storage battery when connected to a station bus will motorize the generators if their voltage should drop below that of the battery; or when rotary converters are operating in parallel, if the alternating-current power to one machine fails, the unit will be run as a direct-current motor by the other machines on the system. In conditions of this kind the ordinary overload-type circuit breaker will not trip out, because there is no overload; it is therefore necessary to provide a relay that closes its contacts and trips the breaker when the current reverses. Fig. 1 shows such a relay with the cover removed, and Fig. 4 is a diagrammatic scheme of connections.

In Fig. 4, *A* is the magnet frame and *B* an iron core about which the moving coil *C* is free to turn on jeweled

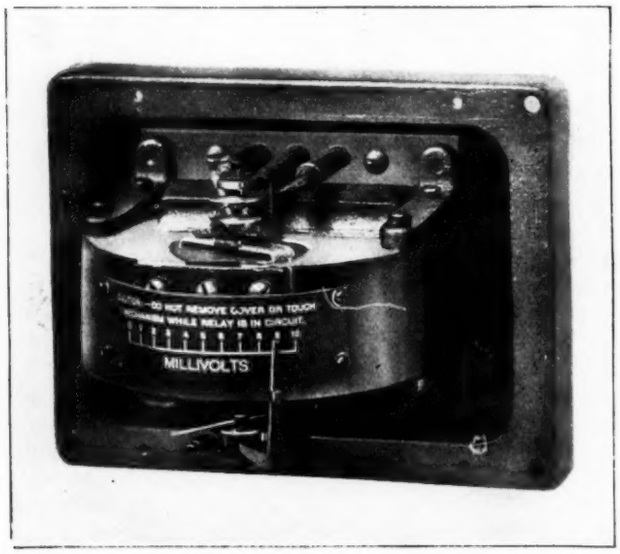


FIG. 1. MOVABLE-COIL TYPE REVERSE-CURRENT RELAY

bearings at the top and bottom of the coil, very similar to the permanent-magnet movement voltmeter or ammeter. The field coil *D* is wound with a large number of turns of fine wire connected directly across the circuit and magnetizes the polepieces *N* and *S*. It will be noticed that the potential on coil *D* does not reverse, no matter which way the current is flowing in the circuit; consequently, the polarity of the magnet is always the same. The movable coil is connected through spiral springs, the same as a movable coil in a direct-current ammeter or voltmeter, to the shunt, which is in series with the load. When the current flows in the proper direction, the turning effort, or torque, of the movable coil tends to keep the contact *E* firmly against the stop *F* and is also held in this position by the spiral springs. But if the current reverses in the circuit, the current through the movable coil is reversed, consequently the torque, therefore contact *F* moves over against *G*. This closes a circuit to the shunt trip on the circuit-breaker and opens the circuit. Or if desired, it may close a definite time-limit relay, which in turn closes the trip circuit. The position of the stop *F* and the contact *G* is variable, so that the contacts will not close until the load has reversed to a definite predetermined amount. This relay has a scale marked in millivolts, as shown in Fig. 1, and may be set to act as low as 2 per cent. reversal of current or as high as 100 per cent.

The closing torque of this relay is proportional to

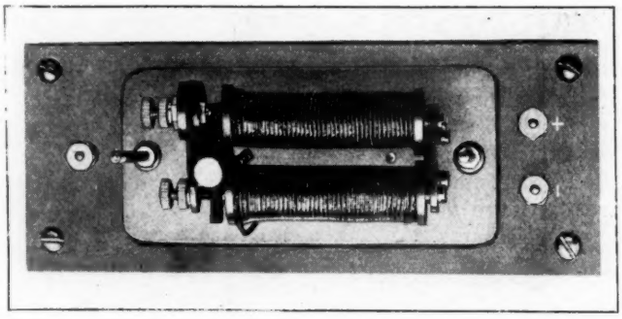


FIG. 2. POLARIZED REVERSE-CURRENT RELAY

the load, owing to the restraining effort of the spiral springs, consequently can be used as an excess-current relay since its time is inversely proportional to the excess current. Thus if the disturbance is mild, it may take as high as 8 seconds to close, allowing ample time for a transient disturbance to clear itself. If the disturbance is more severe, it may take only 1, 2 or 4 sec., depending on the violence of the disturbance, while on a dead short-circuit the action in closing the contacts is almost instantaneous.

Fig. 2 shows another type of reverse-current relay, which is not, however, capable of such accurate protection. A schematic diagram of this relay is given in Fig. 5. *A* is a permanent bar magnet, with poles *N* and

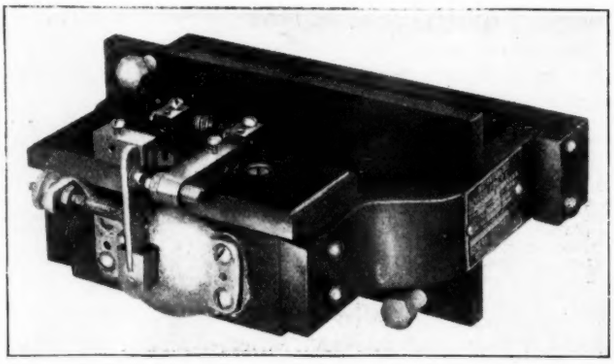


FIG. 3. REVERSE-CURRENT RELAY ARRANGED FOR BUS-BAR MOUNTING

S. Pivoted on the end of the magnet is an iron armature *B* which has its ends polarized *N'* and *N'* by magnetic induction. The iron cores of coils *C* and *D* also serve to complete the magnetic circuit of the bar magnet. The coils are wound to produce poles *N* and *S* at the armature end with the current flowing in a normal direction. Then the *N* end of the lower coil repels the armature *N'* and the *S* end of the upper coil attracts the

armature. This keeps the contacts *E* and *F* open. Should the current reverse, the polarity of the electromagnets is reversed and the armature end of the lower

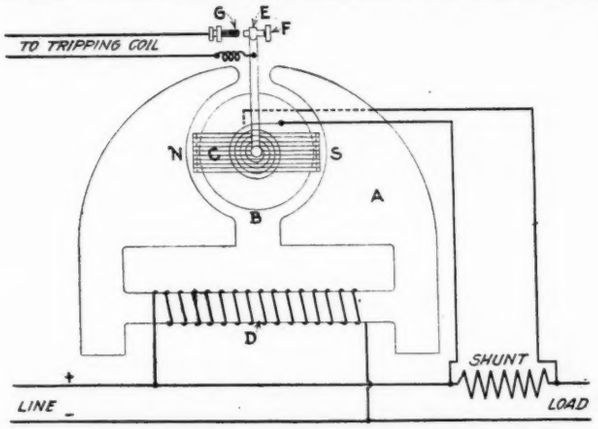


FIG. 4. SCHEMATIC DIAGRAM OF THE MOVABLE-COIL TYPE RELAY SHOWN IN FIG. 1

coil will become *S* polarity, which will attract the armature *N'* while the upper coil will become *N* and will repel the armature *N'*; therefore the armature moves over and closes the contacts *E* and *F* on reversal of the current, which in turn may close the circuit to a relay switch, definite-time-limit relay or the shunt-trip coil on the circuit-breaker.

The relay may be adjusted to operate on a definite reversal by changing the position of the stop *G* or by varying the millivolt drop across the relay-coil leads. The millivolt drop may be obtained by connecting across a length of copper busbar. Allowing 1000 amperes per

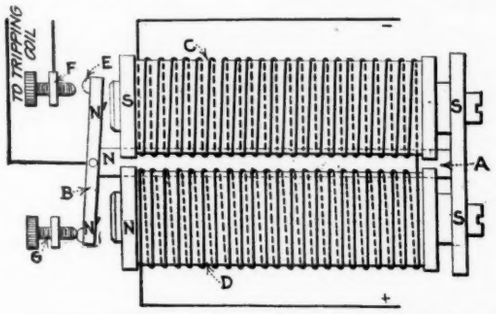


FIG. 5. SCHEMATIC DIAGRAM OF REVERSE-CURRENT RELAY SHOWN IN FIG. 2

square inch of cross-section, 6-ft. length of busbar will give 50 millivolts drop. A correspondingly heavier current per square inch will give the drop with a shorter span. Care must be taken that the relay leads span only the solid copper—that is, there is no joint included —as a slight resistance of a joint may equal several feet of busbar and the resistance of a joint is generally unstable. The drop obtained in this manner will vary greatly with the heat, as the resistance of copper in-

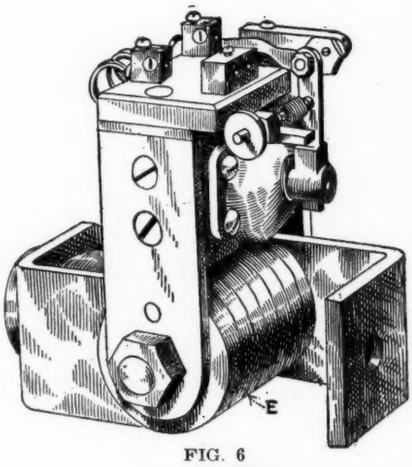


FIG. 6

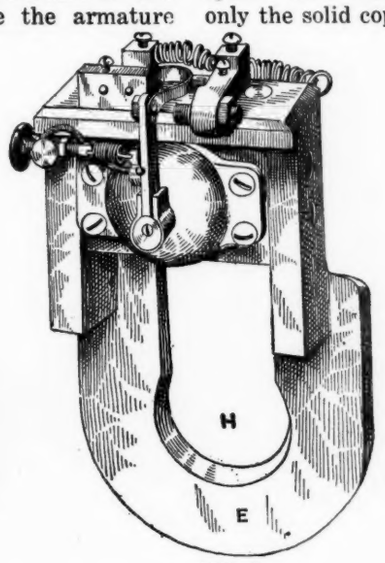


FIG. 7

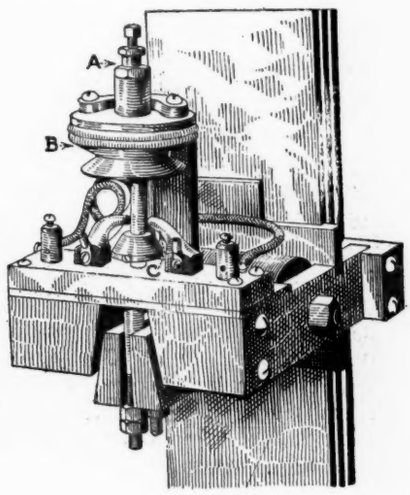


FIG. 8

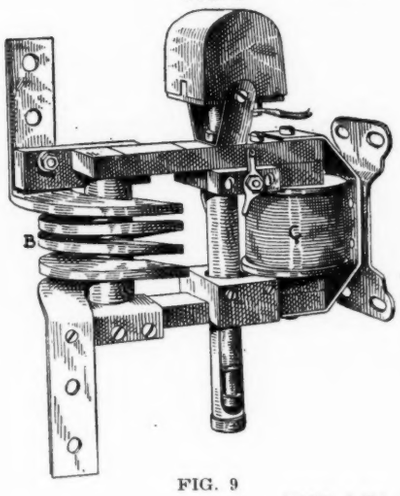


FIG. 9

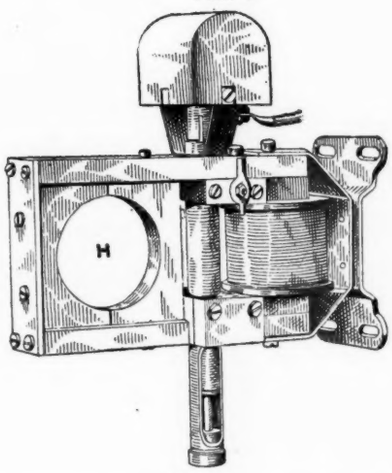


FIG. 10

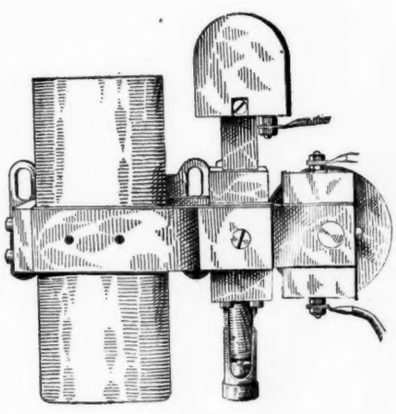


FIG. 11

FIGS. 6 TO 11. DIFFERENT TYPES OF REVERSE-CURRENT RELAYS

creases with a rise in temperature. This, however, should cause no trouble, as reverse-current relays should never be set or reliance placed on a setting when a variation of 5 to 10 per cent. might mean the difference between correct and incorrect operation.

In Fig. 6 is shown a type of reverse-current relay that has its current and potential coil reversed from that in Figs. 1 and 2. The exciting coil *E* is wound with heavy copper strap, and the movable coil located in the upper part of the relay is wound with fine wire placed in series with a resistance and forms the potential element, or in other words, is connected across the circuit.

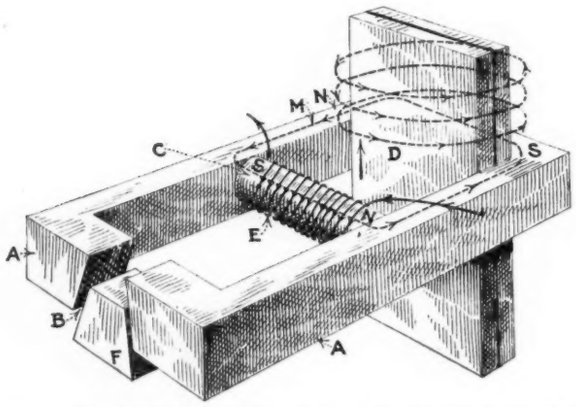


FIG. 12. SCHEMATIC DIAGRAM OF REVERSE-CURRENT RELAY FIG. 8

In the relay shown in Fig. 7 the current coil is dispensed with, as the iron yoke *E* forms the winding and gives enough magnetism for operation simply by passing the circuit-breaker stud or terminal, where the relay is mounted, through the hole *H*. Fig. 3 shows a similar type, but is arranged for mounting on a busbar. The reverse-current relay, Fig. 8, operates on a somewhat different principle from those in Figs. 3, 6 and 7. This is shown diagrammatically in Fig. 12. The iron magnetic circuit *A* has a gap *B* on one side and an iron yoke *C* across its center. If the current in the heavy busbar *D* is flowing in the direction of the arrow, it will magnetize the yoke of a polarity as shown. The winding *E* is wound with a large number of turns of fine wire and is connected across the circuit so as to produce a polarity in core *C*, as indicated. It is evident that the effect of the current in the busbar and that in coil *E* is such as to cause a flow of flux through the magnetic circuit formed by the magnet *A* and the yoke *C* of the potential coil *E*, as indicated by the dotted line *M*. Very little magnetism will flow through the part of the magnetic circuit containing the air gap *B*. Should the current reverse in the busbar, however, the magnetism will also reverse and oppose that of coil *E*, but they will both unite in forcing the magnetism through the part of the circuit containing the air gap *B*. In air gap *B* is an iron core *F*, and when the magnetism becomes great enough, the core will be attracted upward, thus closing the contacts *C*, which are shown clearly in Fig. 8. This type of relay is given an inverse-time characteristic by equipping it with a retarding bellows *B*, which may be adjusted by the air valve *A* on top of the relay.

Another slightly different form of reverse-current relay is shown in Fig. 9. An iron plunger is used and two coils are placed on opposite legs of the iron magnetic circuit. The arrangement is shown diagrammatically in Fig. 13. The iron magnetic circuit *A* and A_1 has a current coil *B* on one leg and a potential coil *C* on the other leg, with a core *D* located between *A* and A_1 arranged to move vertically. With the current flowing in normal direction the magnetism travels up one leg and down the other, as indicated by the arrows. There is no magnetism or at least a very weak field in the core *D* under normal load. Should the current reverse in *B*, then both coils tend to force the flux through the core *D*. When this reversal is sufficient to force enough magnetism through the core, it is lifted up and closes the contacts *E* and *F* by the contact disk *G*, as in Fig. 14, which in turn closes the circuit to a breaker-trip coil.

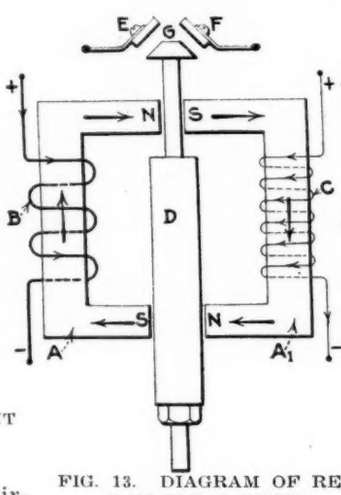


FIG. 13. DIAGRAM OF RELAY FIG. 9 OPEN

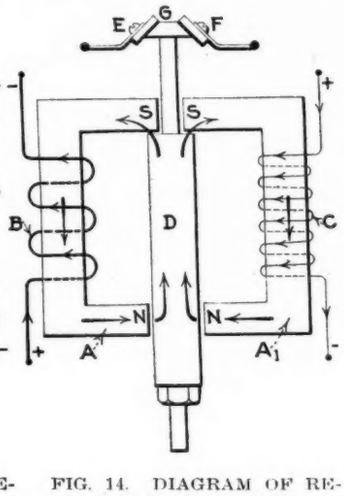


FIG. 14. DIAGRAM OF RELAY FIG. 9 CLOSED

When the current is 1000 amperes or more, the current coil is omitted and a relay like Fig. 10 is used, the cable or bus passing through the insulated hole *H*, the magnetic field set up about the cable being sufficient to operate the relay. If the relay is to be used with a vertical busbar instead of a horizontal one, the parts are slightly rearranged as shown in Fig. 11, but the principle of operation is the same.

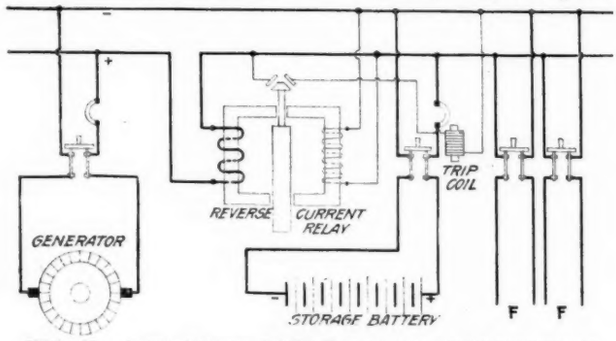


FIG. 15. REVERSE-CURRENT RELAY CONNECTED IN GENERATOR AND BATTERY CIRCUIT

In Fig. 15 is shown a typical case for protecting generators from a reverse current from a storage battery. Under normal conditions the battery is either being charged or it supplies power in parallel with the generator to the feeders *F*. In either case the current will always flow along the positive bus toward the feeders *F*. However, if the generator voltage was to fall below that of the battery and current began to flow from the battery into the generator, the reverse-current relay

would act and trip the storage-battery breaker. Of course this condition could be reversed and have the reverse-current relay trip the generator off the line and allow the battery to carry the load. A similar protection is afforded rotary converters against being motorized from a storage battery in case of failure of the alternating-current power source, by placing the trip coil that is energized by the closing of the reverse-current relay on the converter's circuit-breaker. If several machines are operating in parallel and it is desired to protect each machine from reverse-current operation, then a reverse-current relay must be connected in on each machine. Sometimes there is apparatus that must be run without interruption except in case of actual damage to the apparatus itself, and even then the interruption must be confined to the smallest possible areas. To this end spare feeders or lines are often run to each piece of apparatus, and in case of trouble on one line the other is switched on.

If the apparatus is connected in a ring system, and reverse-current and definite-time-limit relays are properly connected into the circuits, the faulty feeder or piece of apparatus may be automatically cut out without interruption to the rest of the system.

If desired, under special conditions, most reverse-current relays may be adjusted to open the breaker when the load merely drops, instead of a full reversal, by making the contacts normally closed and using the current in normal direction to hold them open; the breaker will then trip on either a fall in load or on reverse.

C. E. C. Tube-Scraping Device

In the average boiler plant euipped with forced draft and burning bituminous coal, small sizes of anthracite or coke breeze, it is usual to operate the boilers at considerably above their rated or nominal capacity. High ratings are obtained by high air pressure under the grates, the effect of which is to lift from the grates small particles of incandescent coke and ash, which are carried through the boiler with the furnace gases. Some of this coke or ash adheres to the bottom and sides of the tubes in the bottom row above the fire.

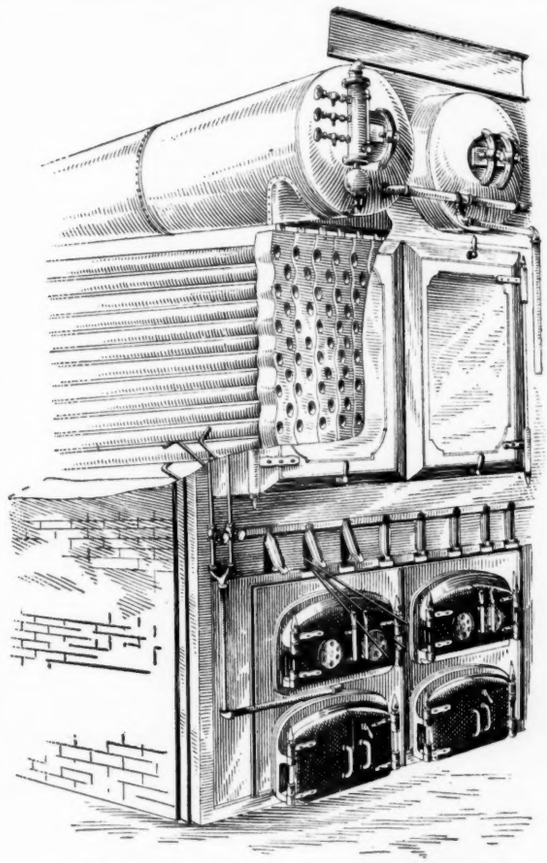
A gradual building up of this cinder continues, closing the opening between the tubes so that the area of the gas passage is in time materially reduced, often so much as to reduce the capacity of the boiler. This cinder can be dislodged by cutting the boiler out of service and then scraping the cinder from the tubes, but this is an expensive operation and would be unnecessary if means were provided to make it possible to scrape the tubes while the boiler is in service.

The usual tube-dusting doors provided in horizontal water-tube boiler settings do not give access to the under side of the bottom row of tubes. To meet this condition the Combustion Engineering Corporation, 11 Broadway, New York City, offers the C. E. C. tube-scraping device consisting of tube-scraping door casting, bottom-tube scraping doors, tube-cleaning or scraping-wall boxes, access doors for tube scraping, as illustrated, the purpose of which is to provide openings in the front or rear wall of a boiler setting through which a light hook may be used for scraping the cinder from the bottom and sides of the lowest row of boiler tubes.

These boxes are made in sections with three, four and five doors which are spaced the same distance apart as the boiler tubes in the boiler in which they are installed. Two or more sections are bolted on angles or Z-bars along the top and bottom sides, providing one opening or door for each space between the tubes. The openings are halfway between tubes so that the sides of the tubes may be reached as well as the bottom, and also the bottom of the second row of tubes.

The castings are of sufficient strength to support the brick wall above them and they will, when placed under the rear header of a horizontal water-tube boiler of the Heine type, support the weight of the boiler also.

The boxes are about 12 in. deep, heavily ribbed vertically between each door or opening. When installed, the brickwork is so laid that the boxes are protected from radiant heat, and being in short sections of 21 to



APPLICATION OF TUBE-SCRAPING DEVICE

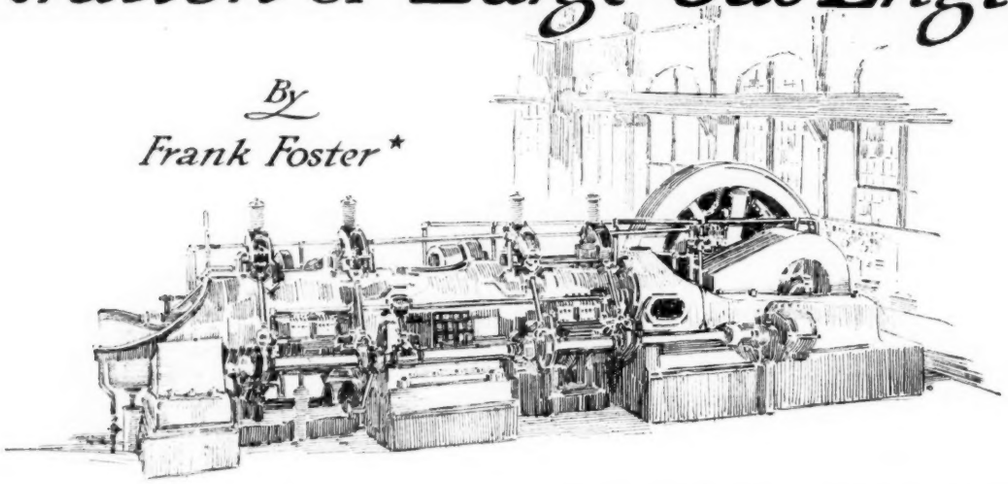
35 in. in length, will not warp and twist and loosen the brickwork above and below.

Each opening is covered by a cast-iron, swinging door or cover, the lower end of which passes behind a tapered spring catch which can be adjusted by a light blow of a hammer to hold the door tightly against the box.

When cleaning the tubes, the attendant takes a rod about $\frac{5}{8}$ in. diameter and 10 to 12 ft. long, of the same shape as an ordinary firehook, with one prong about 5 in. long. By striking a projecting lug on the door, the door is swung to one side and the hook pushed into the hole. The two tubes immediately in front of the opening are then scraped with one or two passes of the hook along the sides and bottom, the hook is withdrawn and the door closed by striking the door lug with the hook. In this manner, the lower tubes may be cleaned once a day or as may be required.

Operation of Large Gas Engines

By
Frank Foster*



Practical points with which the operator of large gas engines should be familiar, such as valve timing, ignition timing, over-rating of power and blower engines and remarks regarding care, cleaning and overhauling.

IN WHAT follows reference is made to the large horizontal, four-cycle double-acting gas engine having two gas cylinders in tandem driving onto one crankpin unless the contrary is stated. In the case of blowing engines the air cylinder is behind and in line with the gas cylinders. These engines run at speeds of from 115 r.p.m. for 1000 b.-hp. size to 94 r.p.m. for 2500 b.-hp. size. Larger sizes are at present obtained by employing four cylinders on two cranks.

Valve timing varies with the make of engine, but good practice lies between the following:

Inlet valve opens 20 to 35 degrees before dead-center.

Inlet valve closes 30 to 45 degrees after dead-center.

Exhaust valve opens 35 to 50 degrees before dead-center.

Exhaust valve closes 15 to 25 degrees after dead-center.

The precise values depend on the shape of the cams and on the gas pressure. Eccentrics call for the later openings and earlier closings as a rule. It will be noted that both valves are open together at periods.

Ignition timing should be at about 25 deg. of the crank before the dead-center when starting, advancing to 40 or 45 deg. at full speed; rather less for blowing engines. This timing must be checked by taking indicator diagrams, which should show a nicely rounded peak, neither too sharp nor too flat.

In starting an electric power engine compressed air is the best medium. A pressure of 220 to 250 lb. is suitable, but most engines will start with 150 lb. if sufficient air is available, although it is not advisable to adopt this low pressure, as the air is supplied to two out of the four cylinder ends.

Assume that air is supplied to Nos. 4 and 3 ends, being those of the back cylinder. The order of firing in European designs is usually 4, 3, 2 and 1 from the rear to the front. The procedure then is as follows:

Open the stop valve in the gas main, but not those on the cylinders. If the engine has been stopped for some time, open the pet-cock on the gas pipe for the purpose of clearing air from the gas mains, keeping it open until the flame burns quietly and steadily. Do not open this cock unless it is known that the gas is under pressure.

See that oil pressure is up and that the suction tanks, lubricators and grease cups are full. Then turn on the supply. Next, bar the engine over until the crank is about 30 deg. over the back dead-center, say 8 per cent. of the stroke, the engine being on the power stroke for No. 4, or the rearmost cylinder end. This is indicated by the cam or eccentric being about 50 geometrical degrees (100 deg. of the crank movement) from beginning to open No. 4 exhaust valve. Then put the air-starting cam in gear and force open the automatic air-starting valves on the back cylinder to see that they are free.

Pull out all ignition switches for the four cylinder ends, close the main supply switch on the ignition board and set the ignition distributor to 25 deg. before the dead-center.

Turn on all cooling water and see that all discharges are running freely. Do not admit water into the exhaust pipes until the engine is running. Then open the compressed-air stop-valve and have a man at the gas stop-valve of the front cylinder.

As soon as the engine is fairly moving, usually after the first stroke, close the ignition switches for the ends 1 and 2 (front cylinder) and slightly open the gas stop-valve on the front cylinder—about one or two turns of the handwheel, according to the type of valve and the gas pressure. Every station is a little special in this respect. The engine will not start if the stop-valve is opened too wide; therefore do not open it until the engine is moving. The front cylinder should now fire and the engine gather speed.

As soon as the front cylinder fires, shut the air off the back cylinder, screw down on their seats the air-starting valves on the back cylinder, close the ignition switches of 4 and 3 and open the gas stop-valve on the back cylinder two or three turns. The back cylinder should now fire, and the engine will gather speed until the governor lifts and takes control. Always stand by the ignition board until the governor is in action.

Next, open the stop-valves on the cylinders, adjusting

*Consulting Engineer, Manchester, England.

the hand controls if necessary and then advance the ignition to 40 or 45 deg. before the dead-center. The engine can then be put under load. Some adjustment of the hand controls may be necessary, however.

When starting a blowing engine, first open the air escape or other starting valves on the air cylinder so as to take off all load at starting. Then proceed exactly as for an electric power engine. Where both gas cylinders are fitted for compressed air and it will not start on one cylinder, admit air to both cylinders until the engine turns over. Then shut off the air to the front cylinder and at once admit gas to that cylinder precisely as for an electric engine.

There is usually no governor on this type of engine, and the engine speed must be governed by a handwheel control.

To put load on the engine open the stop-valve in the cold-blast main; open the stop-valve in the air-suction main, if any, and gradually close their air-escape valves on the blowing cylinder.

In running the engine be systematic. Clean and inspect periodically to program and keep the engine, house, basement and auxiliaries clean. Also watch the gas and water for cleanliness and temperature. The gas temperature should not exceed 70 deg. F. except in summer, when it can rarely be much below atmospheric. It should contain not more than 0.01 gram of dust and tar per cubic meter (about 0.005 grain per cubic foot) and no suspended moisture. Dry gas is as important as clean gas.

The water temperature should not exceed about 70 deg. F. at the inlet to the engine, but here again atmospheric conditions in summer may lift it. Provided sufficient water is available, no harm will result. The water must be free from acids and suspended matter and should be soft.

Outlet-water temperatures should, in general, be kept below 120 deg. F., but it may be necessary to use higher temperatures, particularly for the pistons and exhaust-valve boxes. A limit of 150 deg. F. is desirable. Remember that there are local hot points which throw down scale at quite moderate water-outlet temperatures.

Keep the water flowing in reduced quantity after stopping the engine until the outlet is cold. Shut off the piston water last. Otherwise the heat stored in the engine will throw down scale in the stagnant jacket water. Piston water should be under a pressure of 50 lb. per sq.in. For blowers 40 lb. is sufficient on account of the lower speed. The water flow should be adjusted for variations of load, but not for rapid fluctuations. Take check temperatures as may be necessary. Water for the exhaust pipes (injection) should be admitted after getting the engine running and shut off before actually stopping. Hard and salty waters are objectionable for exhaust cooling and silencing.

If the gas is richer than the average, less gas and more air are required. Adjust the hand controls accordingly.

Preignitions may be due to overloading the engine. Explosions in the exhaust are frequently due to a bad mixture, usually too weak a mixture. Adjust the hand controls to suit.

The main bearings, slides and connecting-rod lubrication is generally fed from a common service. About 20 lb. pressure is usual. Too much oil in the cylinders, stuffing-boxes and exhaust-valve spindles leads to carbonaceous deposits and must be avoided. On the other hand, insufficient or unsuitable oil cannot be tolerated. A good oil gave the following results:

Flashpoint, open test, deg. F	450
Acidity as H_2SO_4, under, per cent	0.015
Loss by heating 6 hours at 212 deg. F.	*nil*
Loss by heating 6 hours at 370 deg. F. under, per cent	3.0
Fatty oils, per cent	*nil*
Resinous oils, per cent	*nil*
Absolute viscosity at 100 deg. F., per cent	0.70
Absolute viscosity at 200 deg. F., per cent	0.115

In Europe it is usual to use one oil throughout the engine, in which case an oxidizing, or sludging, test is important. The consumption in 24 hours for an electric engine should be about 8 Imperial (9.5 U. S.) gallons per 1000 kw. rating. For a blowing engine about 4.5 Imperial (3.75 U. S.) gallons per 1000 brake-horsepower blower rating, in 24 hours.

Hot piston rods are usually local and generally due to dirt in the stuffing-boxes. If possible take the load off the hot cylinder end, and in any case reduce it. Whenever possible slow the engine down but do not stop. If very hot, syringe the rod with oil. Putting a slug of kerosene through the box by means of the force-feed lubricator sometimes acts beneficially, but often it dislodges more carbonaceous deposit—if the box is in a dirty condition—and leads to other troubles.

For indicating use a heavy mainspring (about 200 lb. to the inch) and a light spring (about 10 lb. to the inch) and take indicator diagrams once a week. A diagram taken with the former spring gives general information and also the nature of the ignition. A nicely rounded explosion peak should be aimed at. If the ignition is too early, the peak will be very sharp. This slightly improves the economy, but increases the wear and tear on the engine. The engine will pound on turning the centers if the ignition is too early.

The light-spring diagram indicates the action of the valve timing, which is usually permanent, and also the influence of the hand controls, which sometimes get badly set. The desirable features are as follows: The reversals of the pencil line should be blunt rather than sharp at both ends; the suction and compression lines should cross the atmospheric line near their respective ends; and the pressure of the exhaust above atmosphere and of the suction below atmosphere should be small.

The engine expands to the rear when working, and this sometimes causes the brushes to short-circuit the rings of the ignition distributor. Adjustment of the distributor in relation to the brushes puts the trouble right.

Dirty or wet gas, or excessive or unsuitable oil, will make the engine dirty and lead to preignitions. If these occur at normal loads, the engine requires laying off for cleaning.

Leakage of gas past the joints between the cylinder and the covers, valve boxes or ignition plugs is dangerous. It is most likely to occur at the exhaust-valve seat. The engine should be stopped and the joint remade.

Leakage of gas from the stuffing-boxes must not be allowed to go too far, but a wisp of gas is not immediately dangerous. Blowing past the exhaust-valve spindle is noisy but not vital and can wait a moderate time for attention.

Test the CO_2 in the exhaust gases once a week to check the combustion and efficiency of working.

Cleaning and overhauling should not be overlooked, as much depends upon conditions, but the following is a useful guide: A general overhaul should be made every six months. The time may be increased to nine or twelve months if experience shows this to be safe.

Wash out the cylinder and cover the jackets every two months, more or less as experience dictates. Clean the stuffing-boxes every six weeks to six months according to the type of box, class of oil, cleanliness of gas and as experience dictates. Remove and attend to the ignition plugs every six weeks to three months as experience shows desirable. Remove and clean water-cooled exhaust-valve seats every two to six months as found necessary.

When getting the engine ready for service, pay particular attention to the following points: All cylinder joints to be thoroughly first-class; all joints, sliding or fixed, on the piston water service to be first-class; piston-rod coupling to be screwed up hard; cylinder covers to be screwed up hard and the oil filters cleaned frequently.

Changed Ammonia-Condenser Piping

BY W. T. MEINZER

I was operating a 10-ton absorption ice machine having submerged condensers, and the amount of city water that went to waste caused considerable worry, therefore plans were laid to save it. The piping as originally laid out provided a cold-water connection to each tank, the overflow going to the sewer. The piping shown in Fig. 1 indicates the changed layout, which was arranged to make the flow of water counter-current to the flow of heat in the ice machine as far as possible.

The problem of getting the water out of the second condenser tank and through the absorber into the upper tanks was at first a hard one to solve, but it was eventually done by installing a water-operated ejector in such a manner that the water was taken from near the top of the tank and forced through the apparatus by the pressure in the street piping. Water for the second condenser was supplied by a separate pipe carried to the bottom of the tank, which was removed by the ejector. The speed of the pump was controlled by the height of water in the first weak-liquor cooler. To do this a diaphragm valve was placed in the steam-supply pipe to the pump and a ball-operated valve was placed in the weak-liquor cooler. The ball valve was installed upside down so that the valve opened when the water rose and closed when it fell. A $\frac{3}{8}$-in. pipe connected the diaphragm chamber of the steam-pump valve and the ball valve. Connected to this was a $\frac{3}{8}$-in. pipe from the street water-pressure supply pipe having in it a valve to regulate the amount of opening. With the water low in the weak-aqua tank the ball valve would be closed, and water pressure admitted to this pipe would close the diaphragm valve, stopping the pump. When water rose in the tank the ball-cock would open, relieving the pressure, the diaphragm valve would open and the pump would start. The leakage into the pipe was regulated by the valve. The water wasted from the ball valve ran into the tank and was pumped with the other water into the house.

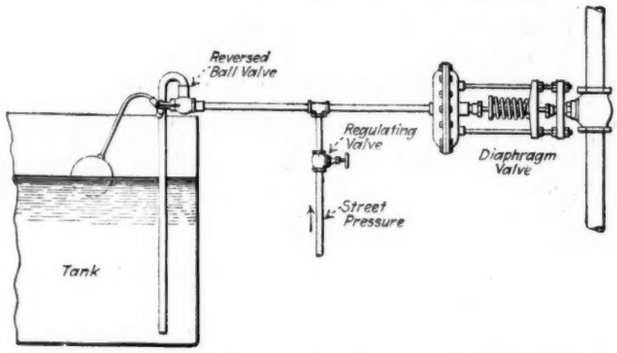


FIG. 2. BALL VALVE AND DIAPHRAGM VALVE CONNECTIONS

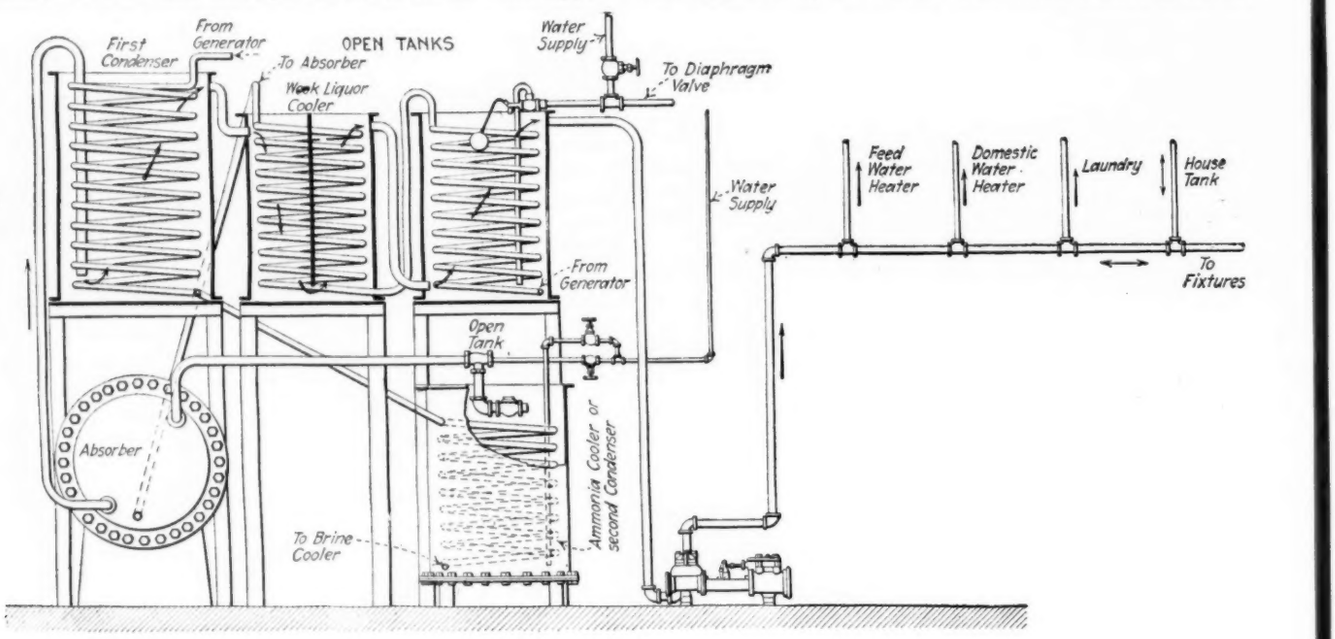


FIG. 1. PIPING SHOWING CHANGED LAYOUT OF THE CONDENSER SYSTEM

When this system was put in operation, it was found that nearly enough water was used on the ice machine to supply the building for other purposes, and as we did not then have to save on the water for the ice machine we were able to use more of it and get lower head pressure on the ammonia, with a consequent saving of steam to operate the pumps and generator. The slightly warmed water was welcome in the laundry and

saved steam there and in the hot-water tanks where steam, either live or exhaust, is used to heat it any way. The drinking-water system is an independent one and is supplied by a separate pump so that the slightly warmed water did not cause any complaint. As a result of the chill being taken off the water, the piping did not "sweat" in the bathrooms, etc.

It was found that these tanks as piped acted as water purifiers, as all of them collected large quantities of mud, which had to be washed out through valves placed in the bottoms for this purpose. The slight heating of the water and the slow movement of it through the tank facilitated this action. Of course this meant less scale in the boilers and piping. Makeup water necessary to keep the house tanks full was supplied by another pump, regulated by a governor connected to the house-tank supply pipe.

One night one of the engineers purged the absorber, by sticking the hose from the purge valve into the condenser tank. The next day the chef complained that there appeared to be an ammonia leak in the kitchen somewhere near his range. I investigated and found that the ammonia odor came from the pot that he was using for cooking, and I immediatey started to test my condensers, etc., for leaks. When discussing the trouble with the night-engineer, the mystery was solved and he was requested to purge into a pail thereafter.

The housekeeper used large quantities of aqua ammonia for various cleaning purposes and sometimes would come to me for a little when his supply ran out. One day I secured a large water bottle and filling it with water arranged it so that when purging the absorber we would purge into this bottle. Escaping gas would be absorbed by the water, and when it became charged to about 10 deg. Baumé I would turn it over to the housekeeper and set a fresh bottle of water in its place. The house was saved the expense for this cleaning supply, and the engineer's department did not lose anything by it, as otherwise it would have been thrown into the sewer.

Pneumatic Ash Conveying

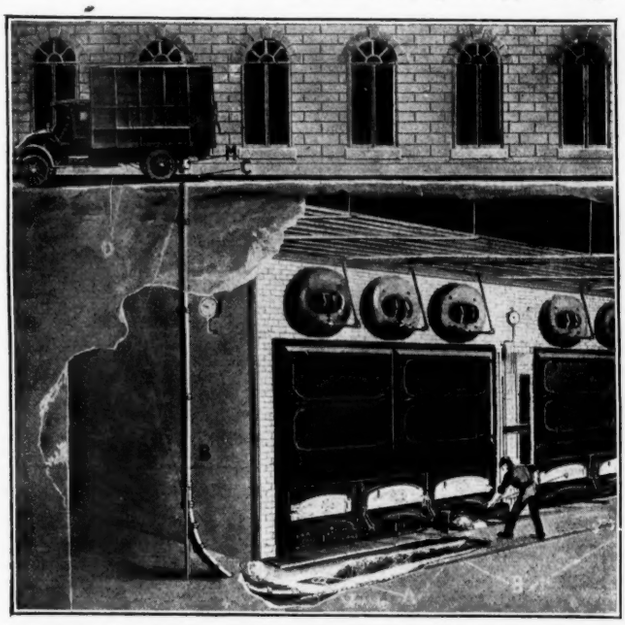
Disposal of boiler-room ashes in the city is, in most instances, an annoyance and generally necessitates the installation of some kind of an ash-conveying system if the slow and tedious method of using ash cans is not used. Generally an ash bin has to be built in which to stow the ashes until they can be removed by trucks. If ash cans are used, there is the labor and city ordinances with which to contend and comply.

The disposal of ashes from the city plants seems to have been solved by the Ash Removals, Inc., 347 Madison Ave., New York City, who have a system that comprises the installation of a conveying pipe in front of the boilers to a point at the sidewalk where a connection is made to a motor-driven ash truck. The system as installed is illustrated herewith.

A 3 x 3 ft. concrete pit is built in front of the boilers and is provided with sectional sheet-iron covers making it possible to uncover any section at will. An 8-in. conveying line *B* extends from beneath the concrete pit and terminates under the sidewalk at the curb. At convenient points in the pit ash intakes are inserted in the conveyor line. These intakes extend to the pit and are flush with the bottom of it.

The conveyor truck consists essentially of a 6-ton chassis equipped with a high-pressure blower driven by the truck motor, a washing device for eliminating dust from the air before exhausting into the atmosphere, a silencer and a steel bin or separator that is placed above the machinery and forms the body of the truck. The conveyor truck connects with the terminus of the conveyor line *B* at the curb by means of an extension pipe *M*, hung on a rocker joint, which allows ample flexibility for alignment in making the connection.

The system operates as follows: Ashes are raked from the boiler ashpit into the concrete pit. Upon the arrival of the conveyor truck, the operator makes the necessary connections to the conveyor line and starts the blower, etc., on the conveyor truck. An assistant enters the boiler room for the purpose of feeding the line with ashes. When all ashes have been removed, the conveyor truck is disconnected from the conveyor pipe, and the ashes are discharged from the bin of the conveyor truck into a dump truck by gravity, through



CONVEYOR TRUCK CONNECTED TO ASH-CONVEYOR LINE

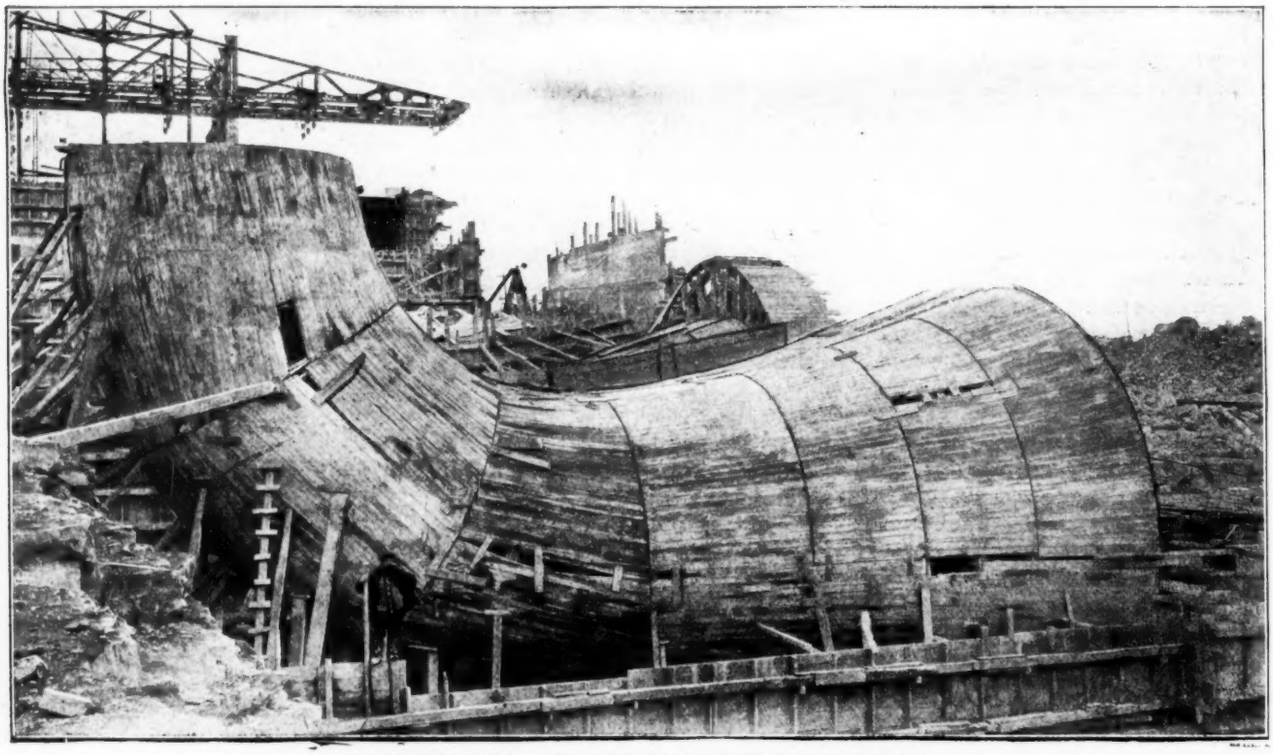
gates. The dump truck then proceeds to the point of disposal, and the conveyor truck proceeds to the next building to repeat the process.

The system is installed under the following conditions: The conveyor line from the ashpit, bin or ash pile in the boiler room to a point under the sidewalk is sold to the plant owner, and for a stipulated sum per annum for a period of ten years the line is maintained against the sulphuric-acid decomposition and the abrasive action of the ashes. The Ash Removals company owns and operates the conveyor trucks and sells this service at a fixed rate per cubic yard of ashes removed, based on the percentage of ashes resulting from a given quantity of coal consumed.

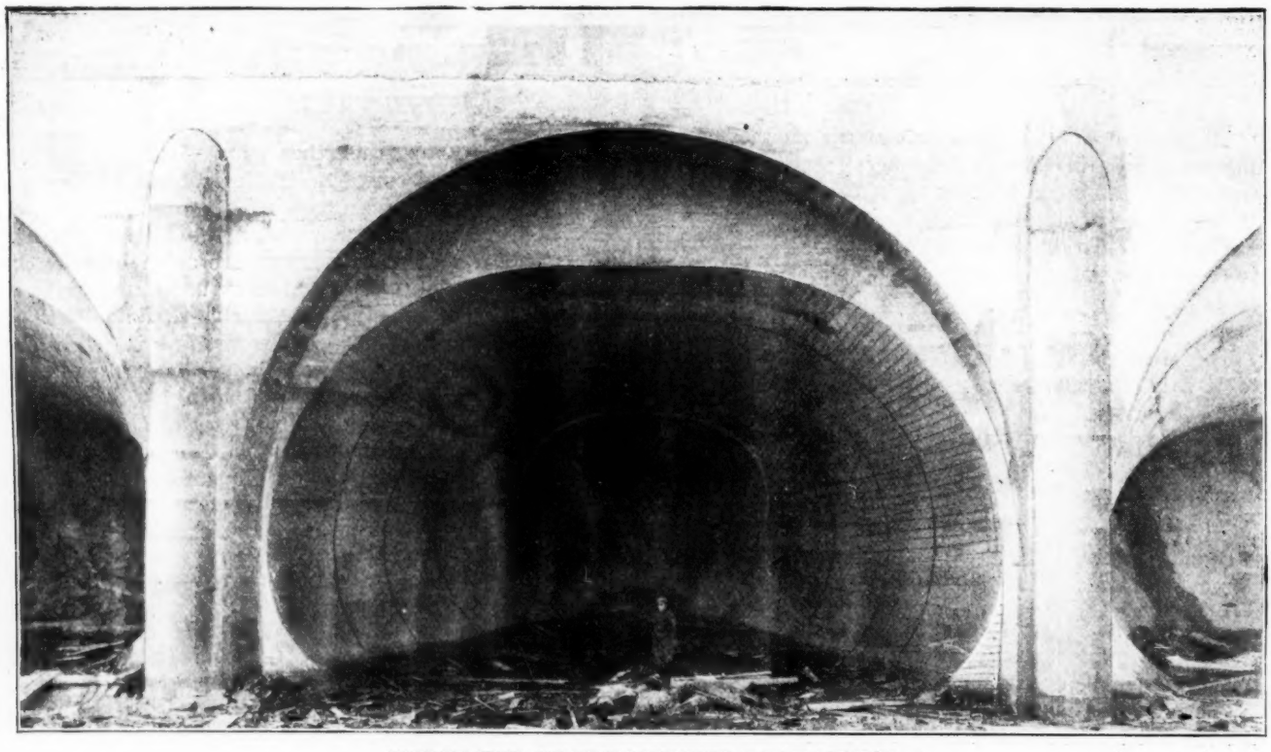
Fear of foreign competition is leading many business firms to overcome their previous dislike for one another and to combine under the Webb-Pomerene Law; while the action of many Government agencies in eliminating competition during the war to facilitate greater production has forcibly impressed all business men with the benefits to be obtained from the mutual interchange of ideas.

Draft Tubes at the Cedar Rapids Plant

THOUGH built some years ago, the draft tubes of this great hydro-electric station, views of which are shown herewith, are interesting, particularly because of the more broad recognition of the possibilities of water power, interconnection of electric systems, etc. The top view on this page shows the wooden forms for the concrete tubes. Their huge proportions are better appreciated by comparison with the man in the left foreground. The picture below is rather unusual and shows the finished tubes viewed from their outlet ends. Notice the man standing in the center foreground.



WOODEN FORMS FOR THE CONCRETE DRAFT TUBES



OUTLET END OF THE FINISHED DRAFT TUBES

Some Hints on Turbine Operation

By H. E. BRELSFORD

The following aims merely to give operators a few hints on some of the important phases of steam-turbine operation.

A TURBINE is a simple piece of apparatus, yet it requires careful attention or there will be large losses attendant upon its operation. The interstage leakage is equivalent in its action and results to a leaky engine piston that lets steam pass through from one end to another or the valve that lets high-pressure steam escape by it directly into the exhaust space and thus do no useful work. This loss on small turbines may easily reach to 25 and 30 per cent. and even on large turbines to as high as 15 and 20 per cent.

Frequently, turbines will run continuously for periods of one, two or three years with no inspection other than of governors or bearings. Then, when dismantled, it is found that there have been serious leaks between stages or through bypasses.

Another large source of loss is in low vacuum, due either to such continuous running as noted above, which makes it impossible to clean the condenser, or to neglect to keep the vacuum pump in proper operating condition. In the region of 26 to 29 in. vacuum the average loss in efficiency is 6 per cent. per inch loss of vacuum. This low vacuum may be due to less than normal speed of the circulating pump or neglect to keep the glands properly sealed, which also cuts down the quantity of water being circulated.

Loss from Excessive Back Pressure on Exhaust

If it is a noncondensing turbine, a considerable loss may result from excessive back pressure on the exhaust due to careless adjustments of the pressure regulator on the feed-water heater or poor vacuum (or no vacuum) on the heater system if the steam goes into such. The loss is from 1½ to 2 per cent. for each pound of back pressure above atmosphere. It reaches a considerable value if the pressure varies from 5 to 50 lb. as it did in one plant recently investigated. Aside from the decrease of efficiency it curtails the power of the turbine.

In spite of the well-known results of superheated steam on turbine performance, it is still the exception to find industrial plants with boilers equipped with superheaters. From wet to extremely wet steam, is the rule, and some installations should have a waterwheel maker's name-plate on them to indicate the actual conditions of operation. Such wet steam results not only in a loss of economy but in a rapid increase of bucket erosion and reduction in efficiency from loss of proper bucket contours. All steam turbines are subject more or less to deterioration under conditions of wet steam. High steam velocities relative to bucket velocity aggravate this condition.

Many of the so-called steam separators on the market are of no use whatever, as the quality of steam on the turbine side of the separator is but little better than on the boiler side. Manufacturers seem to have lost sight of the fact that steam velocities in pipe lines have gone to such high values that there cannot be the same degree of separation as with low velocities. Most separators are much too small in volume and length to be effective.

Turbines are sometimes installed with the exhaust piping rising from the turbine and no drainage or inadequate drainage provided. The writer has known of cases where the last one or two wheels of a turbine were constantly rotating with part of their periphery submerged in water that remained in the exhaust piping and backed up into the turbine casing. The loss of power in rotating even a thin disk at high speed with only a fraction of an inch of its rim contact with water is great. The water not only absorbs large amounts of power, but rapidly spoils the turbine buckets and in most cases will eventually loosen the turbine disks on the shaft. This destroys both the disk and the shaft as a rule and means, of course, shutdown, expense for repair parts and for installing them. See that a liberal-sized drain has a properly operating trap attached or other means of getting rid of all the water.

Testing the Vacuum Breaker

A condition productive of accidents is often encountered where turbines are connected to jet condensers by short pipes. Most such condensers are equipped with proper vacuum breakers that prevent flooding of the turbine if the condenser pump stops. There is always the possibility of such vacuum breakers sticking and they should be tested occasionally. Do not test them when the main unit is running or even warm. Build up a vacuum with the main unit stopped, then suddenly shut down the condenser removal pump and notice whether the water goes into the turbine. If the vacuum breaker operates properly, it will prevent this. On several occasions the writer has seen large turbines stopped almost instantly from full speed by the condenser flooding the turbine. Such an event puts enormous strains on the turbine rotor, and in two cases it twisted off the turbine shaft and partly wrecked the turbine. Beside this it puts temperature stresses in the turbine casing and may make the rotor rub hard before coming to a stop.

Be Prepared for Trouble

If one of the wheels or disks came loose or was wrecked during operation, would you know what to do to remove the disk or buckets and put the turbine back into service? Would you know that the turbine could run under such conditions and that such operation could be continued until repairs were obtained? Would you know how much the power was decreased by eliminating one or more wheels? Would you know how to bring the power up to normal temporarily by installing a bypass in an intermediate stage? Would you know how much more steam would be required to get this additional power so you could determine what size bypass to use? If you installed such a bypass, would you know what connections to make so that the governor would control it and thus prevent overspeeding if the load dropped off?

All these things can be determined, and even if one does not know about them, one should make plans to obtain such information or to at least know how to find it quickly. One can always resort to the expedient of wiring the manufacturer for an expert to come out and solve the problem. At times, however, one may

have difficulty in getting help, as such services are not always available.

One of the first things a person thinks of when looking at a turbine is oil, simply because it is realized that lubrication must be nearly perfect to enable shafting to rotate at such speeds and with such smoothness. Oil may be likened to a suit of clothes. A cheap suit covers one as well as an expensive suit, yet not for the same length of time nor is it so strong for the same weight. It does not protect one so well from the elements. The same things are true of an oil. A cheap, poor-grade oil will not stand up to service so long as a good oil because it actually wears out. Neither is it uniform, and therefore it does not protect the bearing surfaces. The oil may be running all right at one time, and soon the bearings may be heating. Furthermore, the poor oil will not resist outside forces such as the influence of water or extreme heat any more than will the cheap suit. Such elements result in a rapid breaking up of the oil and its total destruction as a lubricating medium. Naturally the fundamental requisite for an oil is that it must *lubricate;* and lubricate is a large word.

Keep Record of Oil Temperatures

A good turbine oil should maintain its lubricating qualities at 150 deg. F., and give a good average life. If oil is too thin at this temperature, the bearing surfaces will wear and the tendency will be for the oil temperatures to rise and the structure of the oil to break up. An oiling system should reach a condition of equilibrium after about two hours' run. Keep a daily log of oil and cooling-water temperature, the oil temperature being kept for each separate bearing. Plot a chart of water and oil temperature for each bearing. If there is a steady tendency for these temperatures to rise from the start, it is quite certain that the bearings are not receiving a sufficient supply of oil, are not fitted properly or that the oil is breaking down. Assuming that mechanical conditions are proper, the oil is to be looked to as the cause of the trouble.

When the oiling system is charged with fresh oil take out a four-ounce sample and keep this corked in a bottle, properly labeled. After a week's run take another sample. Allow it to set for several hours and compare it with the original fresh sample. You will at once notice the presence of any sediment, water or discoloration. Each week take out a sample, label it and compare with previous ones. This gives a visible record of the condition of the oil and in connection with the temperature charts will enable you to keep close tab on lubricating conditions. If the samples show presence of water, it is most important that its source be located and stopped, as water is an active agent of destruction to oils and their lubricating value.

Why Lubricating Oil Discolors

Oil may rapidly discolor. If the surroundings and oiling system are such as to introduce much dust, they will discolor the oil. Water containing chemicals will do the same. Oil containing paraffin and mixed with water will discolor. An oil improperly refined, one mixed with other substances to give it body, or mixed with non-mineral oils will quickly color, and a difference in structure can be noticed almost hourly. Such oils are dangerous and should be avoided.

If you desire to experiment with oils or are intending to use an oil not approved by the turbine manufacturers, then you should accurately test each oil by actual operation in connection with close observation and records.

The Electrical Study Course—Generation of Alternating Voltages

Explains how an alternating voltage is generated in an electric machine, and shows what the value of the voltage will be at different positions of the armature.

IN the preceding lesson the curve of an alternating voltage as generated by a single conductor cutting a uniform field was constructed. In the present lesson we shall plot a similar curve from a generator whose field is uniform and the lines of force in which are assumed to be parallel to one another, as indicated in Fig. 1. The armature has two taps, *a* and *b*, diametrically opposite each other, and is supposed to revolve in a counterclockwise direction as indicated by the curved arrow. At the instant the taps pass the mid-point of the polepieces, which is the position indicated in the figure, the voltage between them will be zero, since the conductors between *a* and *d* will generate a voltage opposite to that generated by those between *d* and *b*, while the voltage generated by the conductors *a* to *c* will oppose and neutralize that due to the conductors between *c* and *b*, as may be seen from the arrowheads on the windings. The turns that pass through the positions *c* and *d* have no voltage generated in them, since they cut no lines of force, and are therefore left blank.

When the armature turns 90 deg., the tap will pass through *c* and *d*, as in Fig. 2. At this instant the voltage across the tap will reach its maximum value as all the conductors between *a* and *b* will be generating voltages in the same direction. When the armature passes through the second 90-deg. position, as in Fig. 3, the taps *a* and *b* are again at the middle of the polepieces, but they have interchanged positions, and as in Fig. 1 the voltage is again zero. When passing through the third 90-deg. position—that is, when the armature has revolved 270 deg., as in Fig. 4—the condition will be the same as for 90 deg., Fig. 2, except that the taps are interchanged, causing their polarity to be reversed. After an entire revolution the cycle of changes would be complete, and it is evident that an alternating voltage has been generated across taps *a* and *b*, increasing from zero in Fig. 1 to a maximum value in Fig. 2, decreasing to zero in Fig. 3, then reversing and increasing to a maximum value again in Fig. 4, after which it decreases to zero as the revolution is completed and the armature comes into the position shown in Fig. 1.

Knowing the value of the voltages for 0, 90, 180, 270 and 360 degrees position, we can begin to construct a curve representing the alternating voltage generated. At 90 degrees we have passed through a quarter turn, or one-quarter cycle, at 180 degrees through a half turn, or one-half cycle; similarly at 270 and 360 degrees we have passed through three-quarters of a cycle and one cycle respectively. The points for the curve that we can plot will therefore be those indicated in Fig. 5 for *h*, *d*, *k*, *c* and *h*. Before the shape of the curve passing through these points can be determined, points for positions of the armature other than those so far investigated must be found.

From the fundamental theory of the generation of voltage we know that the voltage developed is directly proportional to the rate at which magnetic lines of force are cut across. From Fig. 7 it will be seen that when conductor 1 moves from *A* to *B*, it will cut all the lines of force between I and II; also when 2 passes from *B* to *C* it will cut the lines between II and III. We can trace the movement of each of the conductors in this manner until we finally get to conductor 12, which in passing from *N* to *P* will cut the lines of force between XII and XIII. Since the number of lines cut in passing from one position to another is what determines the voltage generated in the conductor cutting them, it follows that the distance between lines I and II, II and III, etc., is a measure of the voltage generated in a conductor as it moves from one to another of the positions. If the distance from I to II is laid off equal to 1, careful measurement will determine the other distances to be those given in Table I.

TABLE I. DISTANCES BETWEEN REFERENCE LINES IN FIG. 7

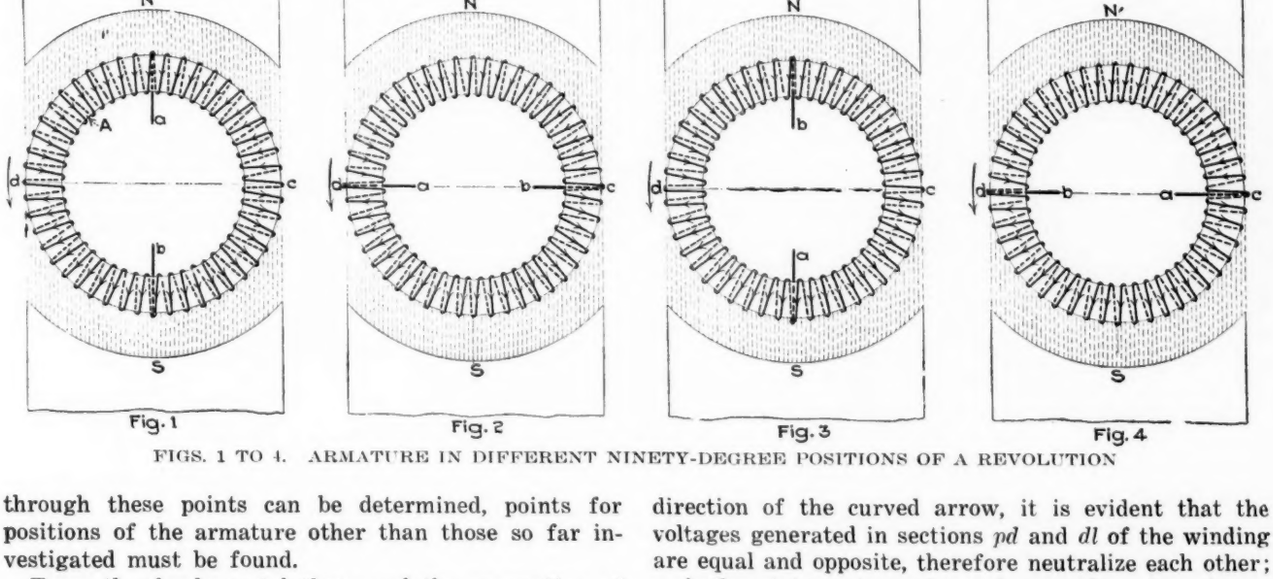
I to II	1.000	V to VI	0.833	IX to X	0.443
II to III	0.983	VI to VII	0.753	X to XI	0.322
III to IV	0.949	VII to VIII	0.661	XI to XII	0.196
IV to V	0.899	VIII to IX	0.557	XII to XIII	0.065

Suppose, in Fig. 7, that in passing from *A* to *B* conductor 1 generates 10 volts; then it is evident that 10 volts is generated for every like distance of field cut across. Since in passing from *A* to *B* the conductor moves from 1 to 2, a distance assumed to be equal to 1, then if we multiply the distance between the reference lines II and III, III and IV, etc., as given in Table I, by 10 volts we will get the value of the voltage generated in each case. Making these multiplications for all the distances given in Table I, we obtain the values of voltages appearing in Table II.

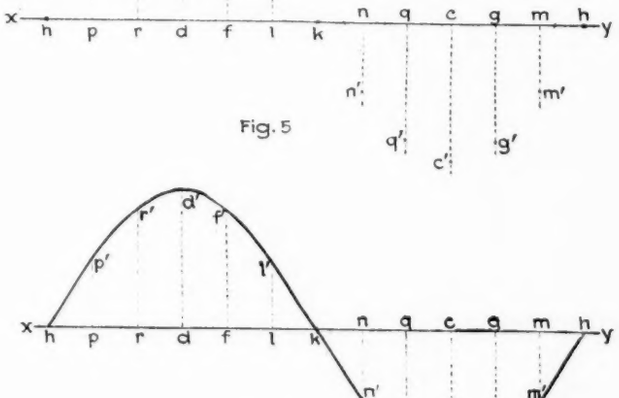
TABLE II. VALUE OF VOLTAGES GENERATED BY CONDUCTORS IN FIG. 7.

	Volts		Volts		Volts
I to II	10.00	V to VI	8.33	IX to X	4.43
II to III	9.83	VI to VII	7.53	X to XI	3.22
III to IV	9.49	VII to VIII	6.61	XI to XII	1.96
IV to V	8.99	VIII to IX	5.57	XII to XIII	0.65

Referring to Fig. 8, which is the same as Fig. 1, except that the armature has turned 30 deg. in the direction of the curved arrow, it is evident that the voltages generated in sections *pd* and *dl* of the winding are equal and opposite, therefore neutralize each other; a similar statement may be made regarding the voltages generated in sections *mc* and *cn*. This will leave sections *pm* and *ln* effective in developing an electromotive force across taps *ab*. The voltage between *pm* is twice that between *hp*. Referring to Fig. 7 the pressure between *h* and *p* is found to be that between I and V. Taking the values from Table II, we have 10+9.83+9.49+8.99 =38.31 volts. Since the volts between *p* and *m* or *l* and *n*, Fig. 8, equals twice that between *hp*, it equals



FIGS. 1 TO 4. ARMATURE IN DIFFERENT NINETY-DEGREE POSITIONS OF A REVOLUTION



FIGS. 5 AND 6. ALTERNATING-VOLTAGE CURVE

38.31×2 or 76.62; that is, the volts across taps *ab*, Fig. 8, equal 76.62.

In Fig. 9 the armature has revolved 30 deg. from the position in Fig. 8. In this position it is evident that the voltages generated in sections *rd* and *df* are equal and opposite, consequently neutralize each other, likewise for section *gc* and *cq*. This leaves sections *gr* and *fq* effective in producing an electromotive force across taps *ab*. The voltage generated in sections *gr* and *fq* is equal to twice that generated in *hr*, which from Fig. 7 is found to be equal to that between I and IX. Taking the sum of the values given in Table II for this section it totals up 66.35. Hence, the voltage between *r* and *g*, and *f* and *q*, Fig. 9, equals 66.35×2= 132.7.

In Table II we have all the voltages in one-quarter of the armature so that by taking their sum and multiplying by 2 we can determine the value of the maximum voltage, or that developed across tap *a* and *b* in Fig. 2 and Fig. 4. Doing so, we find the sum to be 76.66 volts, which multiplied by 2 gives 76.61 × 2 = 153.22 volts as the maximum voltage. We are now in a position to determine the location of the intermediate points of the curve. If we let the vertical distances *dd'* and *cc'*, Fig. 5, represent the maximum voltage, or 153.22, all that will be necessary will be to lay off on the verticals erected at *r* and *p* distances *rr'* and *pp'* to scale equal to 132.7 and 76.62 respectively, the voltage generated in the armature when in the position Figs. 8 and 9, to locate intermediate points on the curve. By connecting these points, a curve representing the voltage on the first quarter of a cycle will be determined. On the next quarter of a cycle the voltage will pass through the same series of values but in the reverse order; that is, decrease from a maximum to zero. Therefore, by applying the foregoing methods to the other three quarters of the cycle, intermediate points *f' l' n'*, etc., will be determined, and by joining these points a curve, Fig. 6, representing the instantaneous voltage throughout the cycle, will be obtained. This curve, it will be observed, is identical in shape with the curve obtained when only one conductor was used in the previous lesson.

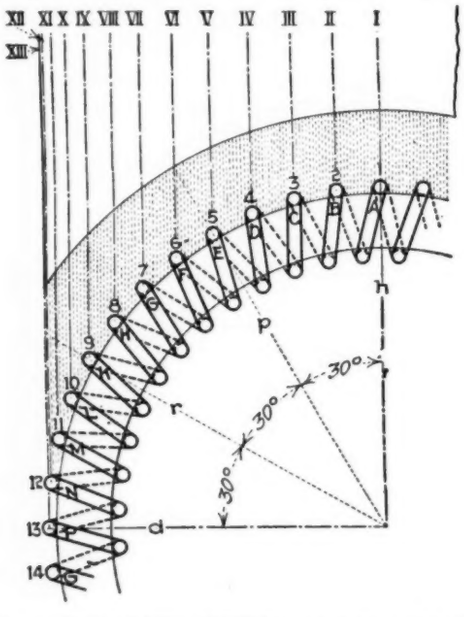


FIG. 7. ENLARGED SECTION OF THE ARMATURE SHOWN IN FIGS. 8 AND 9

In the last lesson the problem given was to find the pull at full load in a 9.5-in. belt when connecting a 25-hp. motor, running 825 r.p.m., to its load. The motors pulley was assumed to be 10 in. in diameter. Since 1 hp. equals 33,000 foot-pound-minute, the motor at full load will develop 33,000 × 25 = 825,000 foot-pound-minutes. The speed of the belt in feet, assuming zero slip and neglecting the thickness of the belt, is

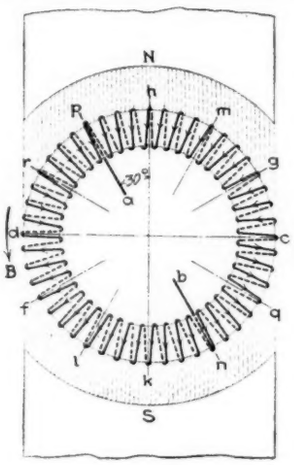


FIG. 8. ARMATURE TURNED 30 DEG. OFF ZERO POSITION

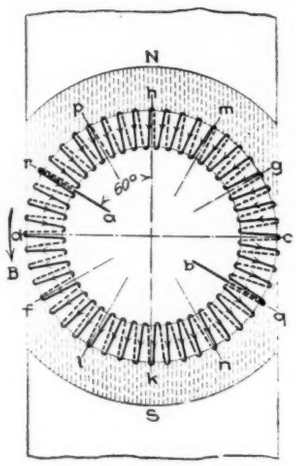


FIG. 9. ARMATURE TURNED 60 DEG. OFF ZERO POSITION

equal to the peripheral speed of the pulley, or this equals $\frac{\pi D S}{12}$, where D equals the diameter of the pulley in inches and S the revolutions per minute; hence the

$$\textit{peripheral speed} = \frac{3.1416 \times 10 \times 825}{12} = 2160 \textit{ ft. per min.}$$

Foot-pounds per minute = pounds pull × the distance in feet per minute, from which *pounds full = foot-pounds per minute ÷ by distance in feet per minute*, in this problem equals 825,000 ÷ 2160 = 382 lb. The motor was assumed to be operating on a 230-volt circuit and taking 95 amperes a full load. Then the *input in hp. = volts × amperes* ÷ 746 = 230 × 95 ÷ 746 = 29.3. Per cent. efficiency = $\frac{\text{Output} \times 100}{\text{Input}}$ = $\frac{25 \times 100}{29.3}$ = 85.3 per cent.

A motor is used to drive a generator; when the generator delivers 225 amperes at 117 volts, the motor current is 73 amperes at 550 volts. The efficiency curve of the motor is furnished and at the load mentioned the efficiency is found to be 82 per cent. Find the efficiency of the generator.

A cylinder that leaks because of open-grained or porous iron can be made steam-tight in the following manner: Make a saturated solution of hydrochloric acid (also known as muriatic acid) and iron drillings; pour this solution into the cylinder or wash the interior of the cylinder with it; then apply ammonia water and a pressure of steam or air. When dry, the cylinder will be steam-tight. The hydrochloric acid solution is made like soldering acid except that iron drillings are used instead of zinc.—*The Combustion Chamber.*

New Heating and Ventilating System for Chicago Schools

By JOHN HOWATT
Chief Engineer, Bureau of School Engineering, Chicago

THE accompanying diagrammatic layout shows the heating and ventilating system designed by the Bureau of School Engineering, Board of Education, Chicago, and now installed and in working condition in the Rezin Orr and the Laughlin Falconer schools. The general design appears so satisfactory that arrangements are being made to use it in connection with the construction of other school buildings.

Standard heating and ventilating equipment as installed in the Chicago public schools for the last twenty years, has been subjected frequently to the following criticisms:

1. The layout called for the installation of long horizontal ducts, which provide ideal places for the settlement of dust so prevalent in Chicago air, from which the dust cannot be dislodged.

2. The plenum-chamber system of ventilation is seriously affected by the opening of the classroom windows, the design being such that the opening of one or two windows will seriously affect the air distribution throughout the entire system.

3. The difficulty in heating and ventilating only a part of the building when desired.

4. The high cost of galvanized sheet-iron work during the last two years.

These complaints were quite general, and it was in an effort to overcome them and provide an improved and more flexible heating and ventilating scheme that the arrangement for the Orr and Falconer schools was developed. This general idea is not original, but is new in Chicago public schools and has some features that may be of interest.

In the new plan fresh air is taken through a shaft leading to the outside atmosphere at the roof line by means of power-driven fans, is drawn through tempering coils, or radiators, which temper the air to 70 deg., and is then blown into a large tempered-air plenum chamber consisting of an excavated space beneath the corridor on the first floor. This excavated space is obtained by removing the earth between the corridor wall foundations down to a point eight feet below the first floor line, then placing a cement floor on the bottom, thereby providing a tunnel or chamber the length of the corridor and fourteen feet wide, or the width of the corridor and eight feet high.

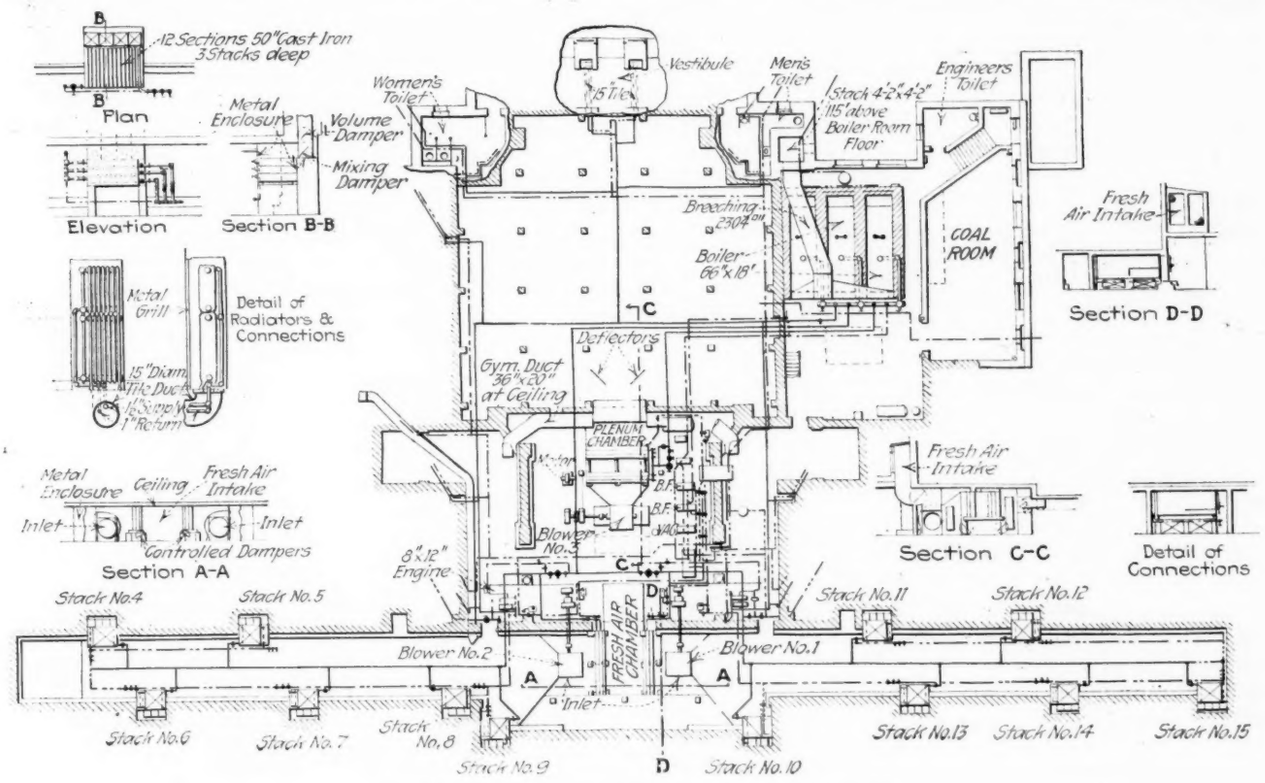


DIAGRAM OF PIPING LAYOUT IN THE SCHOOL

Reheating coils are set below each tier of classrooms in recessed spaces constructed of concrete along each side of the tunnel. From these recesses, if the building is three stories high, three hot-air supply ducts are carried, one to a classroom on each floor. These ducts are provided with automatic mixing damper arrangements whereby the air will be taken either from the reheated air space above the reheating coils, or bypassed around the reheating coils so as to take only the tempered air in the tunnel.

In districts where the conditions warrant, an air washer may be placed in front of each blower, and some air cleaning and air moistening effect may be ob-

tained readily by having a finely perforated water pipe placed across each tunnel near the blower end. Each of these tunnels is provided with water piping and hose connections so that the walls and floors can be washed out daily, the floor being pitched to a suitable drain.

The boiler equipment consists of three 66-in. x 18-ft. standard return-tubular boilers set with the Chicago Smoke Inspection Department's No. 8 furnace. Steam is carried at about 100 lb. gage pressure. The assembly-hall blower is driven by a 10-hp. motor and the two classroom-supply blowers by 8 x 12-in. steam engines.

Some of the benefits that are derived from this system of heating and ventilating are as follows:

1. There are no horizontal air ducts that cannot be cleaned. All ducts are vertical so that settlement of dust in them is reduced to a minimum. The tempered-air space under the corridors is so large, the air movement is slow, and as a consequence dust that is drawn in from the outside settles in this tunnel space, from which it can be washed out daily through the drains by flushing from the hose connections.

2. The design is less costly than the plans formerly used, as much of the sheet-metal work is eliminated.

3. The system is flexible in that if only a few rooms are to be used, just that part of the building in use need be heated, as each individual group of reheating coils is separately controllable. The arrangement also provides for adjustment so that rooms on one side of the building may receive more heat than those on the other side, depending on weather conditions. With the plenum system of ventilation it has been our experience that this factor is not as flexible as it will be with the new design.

4. The arrangement permits to a considerable extent the opening of classroom windows without disarranging of the entire ventilating system in the building.

5. In a recent design of school building the basement has been omitted. This makes it difficult to make changes in the mechanical and electrical equipment after the building construction is completed. With the system designed for the Orr and Falconer schools, all the benefits of the basement-type construction are obtained in so far as the mechanical and electrical equipment is concerned, and repairs and alterations to pipe work can be made readily. Additions to the building can be made by extending the rooms at each end of the corridor, increasing the size of the classroom blowers up to the limit of the boiler capacity.

Hy-Pres Oil Pump

A pump that has a combination of variable capacity, constant speed and constant pressure, is found in the Hy-Pres oil pump, which is positive-acting and in which the volume of liquid handled can be varied while the speed of the pump remains constant. This performance of the pump, which is manufactured by D. H. McCorkle Manufacturing Co., Oakland, Calif., is made possible by the use of synchronously rotating two engaged bodies of different diameters on different centers. Referring to Fig. 1, *A* is the rotor mounted on a driving shaft; *B* is the inner rotating carrier ring, these two parts revolving in synchronism on their two centers; *C* is the abutment of the outer casing, and *D* is one of the vanes. The rotating carrier ring *B* is driven in synchronism with the rotor *A*, but revolves on a different center. The vanes are slidably pivoted in the rotor and pivotally carried in the carrier ring. This mechanical construction relieves the vanes of all driving or cramping strains and at the same time provides a positive mechanical means of keeping them in their proper adjustment during the revolution. The rotating

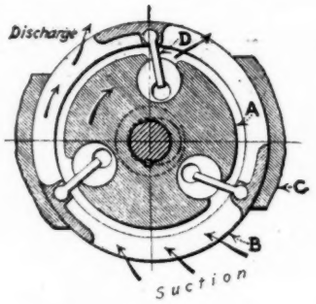


FIG. 1. ROTOR AND CARRIER RING CONCENTRIC

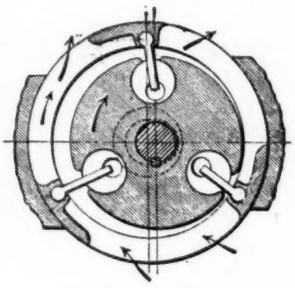


FIG. 2. ROTOR ECCENTRIC TO CARRIER RING

carrier ring *B* has three large rectangular ports in its periphery, which register with the inlet and outlet in the main casing *C*.

In operation, referring to Fig. 1, the center of the rotor *A* and the center of the rotating carrier ring *B* are concentric, and as the displacement is equal on all sides, the parts will rotate without displacing any liquid. By means of an external adjusting handwheel the center of

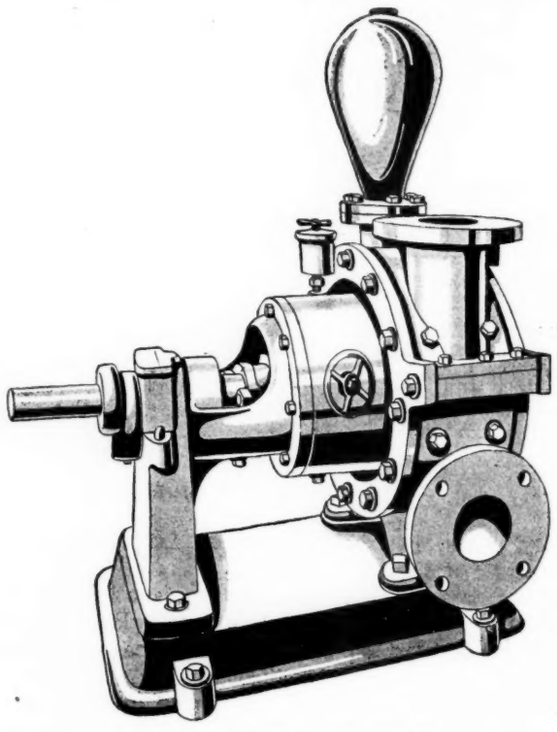


FIG. 3. HY-PRES OIL PUMP

the carrier ring can be moved in a horizontal direction along the center line, as in Fig. 2, and in this position the displacement diametrically across the pump on the center line is unequal. It will thus be seen that the displacement between members *A* and *B* is unequal, and that the volume of liquid forced through the pump depends on the degree of eccentricity between these two revolving parts. The adjustment can be made as slowly or as rapidly as desired, allowing the pump capacity to be varied without affecting the pressure.

EDITORIALS

Fallacies in Boiler Operation

IN A paper read before the American Boiler Manufacturers' Association at its recent meeting in Buffalo, Dr. D. S. Jacobus said some things that will bear wider circulation; not that he uttered new truths, but that he emphasized, in that casual way which is one of his charms, some fallacies not broadly enough recognized as such. Dr. Jacobus enjoys the distinction of being a premier in boiler matters, therefore his words have weight.

One fallacy to which he refers is the importance, as an indicator of boiler efficiency, of certain percentage contents of carbon dioxide in flue gases, particularly where firemen are paid a bonus based alone on this product of combustion. He says, "How high a percentage should be aimed for depends upon the form of furnace and the furnace volume. Ordinarily, with coal it does not pay to exceed about thirteen-and-one-half per cent." It may be said that for many installations one should become suspicious when the percentage of carbon dioxide exceeds fourteen. When it does, with coal as fuel, there usually is present enough carbon monoxide to offset the apparent gain indicated by the high carbon-dioxide content. The aim should be in most installations to get the highest carbon dioxide with no, or but a trace of, carbon monoxide.

When bonuses are paid on a carbon-dioxide basis alone, the firemen will soon discover that "juggling" of fires will net the greater returns although it may cost the owner more than it's worth. But experience shows that firemen might better strive for high carbon-dioxide content than not strive at all. Exerting conscious effort to produce what, broadly speaking, is an indicator of efficiency, they do get somewhere on the road of improvement.

Another fallacy to which he called attention is that of presuming that average flue-gas analysis combined with the known percentage of carbon in the ash is a measure of the efficiency of the furnace. This leaves out of consideration the fact of secondary combustion. Of course all combustion should be completed in the furnace; it should not continue along among the tubes, even away back to the uptake end. Delayed combustion is better than little or no combustion, when there are combustible gases passing through; but results will make it worth while to try to complete the combustion in the furnace proper.

"A general impression prevails that test results are one thing and operating results another, and that the operating results necessarily fall considerably below the test results. There is no reason why this should be so in the majority of cases." It will be a long time before power-plant men will be so convinced of this that there no longer will be cause to make the statement. Most men like to nourish the belief that there is an unbridgeable gap between everyday operation and test operation. But is it so? Not in modern plants, at least. It is the boiler room where the great sources of waste are located, and until recent years it has been the boiler room which was the most neglected part of the plant. But the modern boiler room is much different, particularly if the plant is of large or moderately large capacity. Everything is quite automatically done, even to the breaking and discharge of the ash. The control board is formidable with instruments which, with the intelligence now usual in such plants, enable such exactness of control as to insure without inconvenience a standard of operation equal to that had on tests.

Second-Hand Equipment

DISMANTLING and reduction in size of many of the plants engaged in strictly war work has caused the market to be flooded with large quantities of second-hand machinery and equipment. The matter of deciding whether it is advisable to purchase second-hand equipment of this nature or to install new material confronts many buyers at this time, and the question is an important one because the purchase of the used equipment, if rightly done, offers great possibilities for saving and quick deliveries.

Probably the greatest source of trouble in connection with second-hand purchases is that the average buyer is tempted to purchase such apparatus because it is cheap—even though it does not exactly suit his requirements. Unless used equipment is just the size and type suited for the conditions to be met, it is undoubtedly good policy to let it alone and invest in new machinery, which will do the work at the best efficiency and at the least cost, because the difference in initial outlay can soon be wiped out by increased operating costs.

If used machinery of the proper capacity and type is available, then a careful study of its age, condition, performance, etc., should be first made. This is especially important in the case of pressure vessels. Usually, some information as to its condition can be obtained from the plant in which it was originally installed, but it is frequently advisable to check this information by applying direct to the maker of the equipment, giving sufficient information to enable him to identify it from his records, and then asking for details as to its performance, date of installation, probable life in active service, and also its present cost if new, which last is of value in determining the reasonableness of the price asked. It will usually be found that the manufacturer's recommendations along these lines are well worth while because in the long run he is interested in upholding the reputation of his equipment and endeavoring to prevent a "trouble case" or bad reference.

No second-hand machine ought to be purchased without a personal inspection to determine its physical condition, the completeness of its parts, etc. Inspection of the fittings and bearings is especially important. Frequently, it will be found that the fittings and fixtures that are missing when the machine is to

be installed will more than make up the difference in cost between a used machine and a new one.

Summed up, the purchase of used or second-hand equipment that is fully adapted to the new working conditions, is in good operating condition and is considerably lower in price than new equipment constitutes a good "buy" in the vast majority of cases, but the prospective purchaser should take some pains to determine whether the points mentioned are fully and satisfactorily covered, and not be swayed by the human impulse to "jump at a bargain," just because it is something cheap.

Reverse-Current Relays

DURING the early days of the electrical industry the problem of the protection of circuits and equipment was one in which the chief concern was given to disconnecting the fault as quickly as possible. This generally could be accomplished by the use of fuses or circuit-breakers with an instantaneous trip. However, as the size of electric-power systems increased and they were complicated with a multiplicity of circuits and apparatus, and the necessity of continuity of service became an important matter, the problem of protection developed into one of not only protecting the apparatus, but also of localizing the fault to the circuit on the piece of apparatus where it occurred. To meet the various conditions of protection required for machines operating in parallel or in parallel with other equipment, or for isolating the faulty circuit in the various feeder systems, there has been developed a number of different types of relays. Among these devices the reverse-current relay has, especially in the protecting of direct-current circuits and apparatus, a wide application.

One of the prime applications of reverse-current relays is for the prevention of the reversal and the discharge of current from a storage battery into the charging source should the voltage of the charging equipment fail. In addition to this there are numerous other applications where the reverse-current relays may be used. Rotary converters operating in parallel with a stand-by storage battery is another case in which a highly sensitive relay of the reverse-current type is required. Or where rotary converters are operated in parallel, if the alternating-current supply fails on one machine it will be motorized from the direct-current bus. Even if the alternating-current supply is interrupted only for a short time, it is unsafe to run the converter inverted although the power consumed is very small, since it may run at damaging speed, and in any case, were the alternating-current supply to be established after a very short interruption, the converter would not be running in synchronism and might cause considerable damage. Therefore the reverse-current relay must be highly sensitive and trip the breaker immediately upon a slight reversal of power in the direct-current end.

There are many instances in which reverse-current relays may be applied to give protection to direct-current apparatus and to preserve continuity of service in case of failure of line or machines. While their general use has been limited by the initial cost and the relatively small size of direct-current transmission systems, they are becoming more and more to be recognized as an indispensable factor in the correct operation of any plant. Another reason why they have not come into more general use in the various plants is because the users of the electric energy have grown into the habit of considering an interruption as an unavoidable evil. Were the protective relays better understood, it would at once be realized that interruptions are not necessary evils, but that a large percentage of them on many of the smaller power systems may be avoided by the proper use of protective relays. In an article, "Reverse-Current Relays—Principles of Operation," in this issue, Victor H. Todd describes the principles of operation of a number of different types of reverse-current relays and their applications. A better understanding of the principles of operation of these devices by those who are responsible for their reliable operation will be of great assistance in getting out of the devices that for which they are designed and provide insurance against shutdown.

The perpetual-motion man is again abroad. We have received an attractive-looking circular put out by the United Powers Company, San Francisco, California, heralding the great possibilities of a six-hundred-horsepower fuelless engine. It is said to be the invention of one C. C. Thorn, whose name appears as general manager of the company. But not only have they to offer a six-hundred-horsepower engine requiring not a cent for fuel, but as a side line there is an electric augmentor possessing, according to the circular, the wonderful ability to multiply electricity from four to fourteen times, and still "not a cent for fuel." Oh, yes, a whole page is devoted to the great returns which the unsuspecting investor is to receive.

There is need for closer coöperation between the designing engineer and the architect. The latter always holding the architectural features paramount and usually with a very superficial knowledge of the mechanical details of the power plant, is sometimes responsible for conditions that lead to inefficient operation.

Don't forget that the erecting man may be laboring under adverse conditions with no shop facilities at his command. Therefore, see that the machine leaves the works only after careful inspection and accompanied by all the necessary accessories and tools. It may save days of delay.

The index to Volume Forty-nine of *Power*, covering January to June, 1919, inclusive, is now ready and may be had upon application. If you have saved your back copies, don't fail to get one so that your volume will be complete.

Power-plant records count when they can make a good showing in the balance sheet, but the bookkeeper takes joy out of life when he discloses losses that counterbalance apparent gains.

One rain drop won't make a crop and one Thrift Stamp won't make a fortune, but both usually bring others of their kind with them.

Keep your Liberty Loan interest working for you by investing it in War Savings Stamps.

Correspondence

A Disordered Shaft Governor

The style of governor used on the three vertical compound high-speed engines that drive the electric generators in a large office building is shown in Fig. 1. These governors were originally provided with roller bearings for the pivot pins at the points of attachment between the inertia bars and the spring connectors. A cross-section of these bearings is shown in Fig. 2.

A recent overhauling of the engines revealed that at some previous time the rollers had been removed from these connections, thus leaving each 3/4-in. pivot pin resting upon the periphery of the 1 5/8 in. hole in which the entire bearing previously had been housed. This

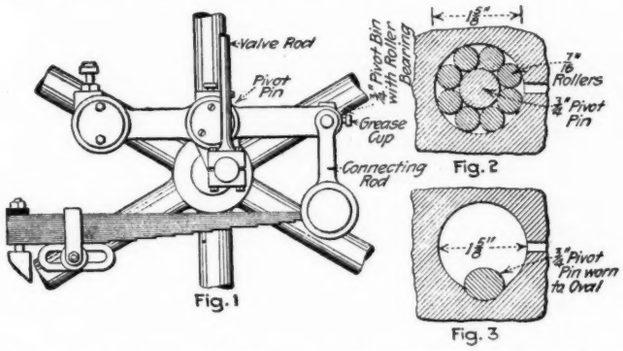


FIG. 1. TYPE OF GOVERNOR EMPLOYED. FIG. 2. PIVOT PIN ROLLER BEARING. FIG. 3. BEARING AS IT HAD OPERATED WITH ROLLERS REMOVED

condition is shown in Fig. 3. That the governors had been running this way for a long period was attested by the fact that the pins were worn oval in cross-section and had hollowed out recesses at their places of contact to a depth of over 1/4 inch.

Notwithstanding this the governors had continued to give fairly good regulation, indications that there was anything seriously wrong with them having been manifested only when wide variations of load occurred. At such times the engines would stagger, perceptibly for some seconds before the governors could adjust themselves to the altered conditions. A. J. DIXON.

St. Louis, Mo.

Don't Take Chances with the Synchronoscope

I was deeply interested in F. J. Gillooly's article, "Don't Take Chances with the Synchronoscope," in *Power*, Apr. 29th issue, since it brings to my mind similar incidents. An operator was synchronizing a 5000-kw. slow-speed alternator direct-connected to a Corliss engine. The alternator had its separate bus-selector and main oil switches. After the operator had closed the main switch, the synchronoscope continued its travels. He then discovered that he had forgotten to close the bus switch; and almost as quickly closed it. In about a minute he opened the switch again, and for half an hour the engineers were busy adjusting the valve gear of the engine, which had been completely thrown out of adjustment by the disturbance of the alternator, which would not pull into step.

In a 5000-kw. plant, where the engines were of an old type and the load carried subject to wide swings, the synchronizing was done with dark lamps. The oil switches were of the "barrel" type. Their tanks were under the switchboard, and they were operated by a rod mechanism with a wheel handle. The switches made a wiping contact by being revolved successively from "Off" to "No. 1 Bus," "Off," "No. 2 Bus" and "Off." The rod carried a pointer which indicated on a dial on the floor the position of the switch. As too strong a turn of the handle would operate the switch beyond the point intended, the attendants made a practice of placing one foot on the dial as a pointer stop.

After a particularly trying siege of synchronizing, one operator gave so savage a turn on the handle that the pointer not only failed to stop at his foot, but traveled up over his shoe and held him prisoner by his toe. To free his foot meant taking the machine off the bus and resychronizing it against the other already overloaded units.

In the 11,000-kw. plant supplying the combined load of a fair-sized city all the primary equipment was located in a basement switchroom. The potential transformers, with their fuses attached to them, were mounted above the oil switches, out of sight from the floor, and near the open busbars, which were protected only by wooden barriers between phases. An operator was being trained, and while synchronizing a 2500-kw. turbo-alternator, he became nervous and closed the switch about 90 deg. out of phase. Then, at the first groan of the generator he tripped the switch out, never giving the machine a chance to settle down and drop into step.

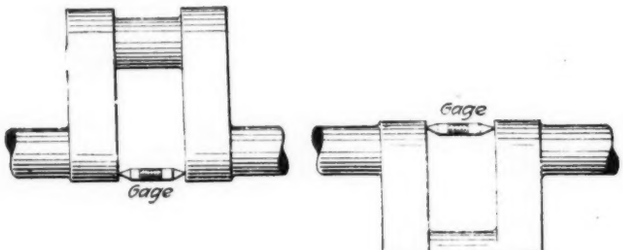
On stepping up to do the job, the regular operator found that he could get no voltmeter or synchronoscope indication. Somewhere "down the cellar," he knew, there was a fuse blown; but the stuff down there was too crowded and dangerous and altogether "too hot for him to go snooping around" in search of an open circuit. Reserve units were not kept warmed up for emergency use in that plant. To turn over the auxiliaries and start another unit might consume an hour. The engineer was anxious to get some load off the running machine, which had become overloaded before the second one was started, as was the customary procedure. He was so insistent that the operator had to accede to his demands. All load was dropped off the bus; both machines were slowed down, then brought up together to speed and voltage with their switches closed on the bus; and the second machine made to carry load with only its ammeters registering.

All of which indicates that the layout of the instrument and control wiring and the location of all fuses and other apparatus should be the intimate knowledge of the operator. R. A. PHILLIPS.

New York City.

Testing Crankshaft Alignment

I have recently learned a new method of testing the alignment of gas-engine crankshafts, which is giving good results, and I pass on the idea in the hope that it may prove useful to others. Place the crankshaft on its top center and with either a micrometer gage or



TESTING CRANKSHAFT ALIGNMENT

one made of round iron, gage between the crank webs at the bottom. Turn the crankshaft around till it is in its bottom position and gage again. It is likely that a surprise is in store when this is done. When the amount that some of them will open is observed, one will not be surprised that so many gas-engine crankshafts break. Usually, it is the bearing on the driving side that is low. A. BENNETT.

Wigan, Lancashire, England.

Cooling-Water Temperature

The vital necessity of a reduced flow of cooling water on low loads in Diesel operation seems not to be generally understood by the oil engineer. With gas or gasoline engines with quantity control or constant explosion, the amount of air drawn into the cylinder, as well as the amount of gasoline vapor, is generally regulated according to the load. On low loads the air suction is choked, producing a lower air pressure in the cylinder at the beginning of the compression stroke. This, of course, results in a lower final compression pressure of the mixture of air and gaseous vapor. In order to raise this to the highest possible value, thereby improving the efficiency, it is always advisable to reduce the cooling-water flow. Doing this raises the cylinder temperature, and likewise the terminal pressure. However, the gas engine will successfully fire the charge practically regardless of the pressure carried, the limiting factor being the leanness of the mixture. The gasoline, being completely vaporized, is of course easily ignited.

The fuel charge of the Diesel engine is injected into the cylinder in a rather undivided condition in comparison with the vapor charge of a gasoline engine. The ignition is achieved solely by the high temperature of the air charge, which at full load will be around 1050 to 1400 deg. F. This temperature is the result of the compressing of the air by the engine piston further augmented by the absorption of heat from the cylinder walls.

Such high temperature is necessary to ignite the relatively large globules of fuel oil. If the temperature is reduced below a certain degree, dependent on the kind of oil, etc., no ignition will occur. If the temperature is dropped below 1000 deg. F., the combustion will be faulty.

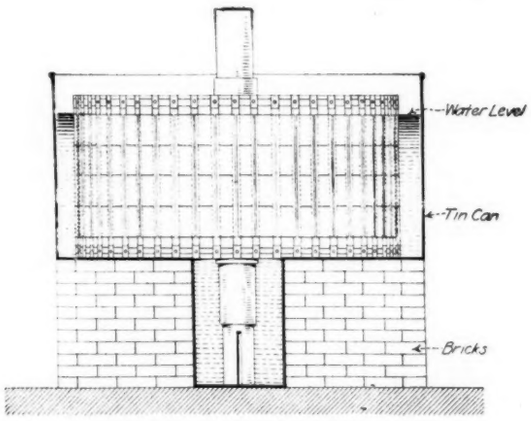
Since the fuel charge is small on low loads, the amount of injection air blowing into the cylinder is greater than at full load. This air, expanding from a pressure of 900 lb. to 500 lb., chills the oil and the cylinder air charge, thereby making the ignition difficulties still more pronounced.

It is then apparent that the temperature, and consequently the compression pressure, of the cylinder air charge must be kept up to normal on low loads. If the cylinder-wall temperature remains constant, then the compression pressure will have a constant value, for the volume of air drawn into the cylinder is always the same at constant temperatures. To obtain a constant wall temperature it is necessary to reduce the flow of cooling water on low loads. The amount of heat evolved from the fuel combustion is reduced, and consequently the amount of cooling water required is likewise reduced. In fact, it is of advantage to reduce the flow until the discharge temperature shows an increased value of from 10 to 15 deg. F. Undoubtedly it would be an improvement if manufacturers placed the cooling-water flow under governor control. E. E. SNOW.

Philadelphia, Penn.

Method for Welding Induction-Motor Rotor Bars to End Rings

We were experiencing considerable trouble with keeping the end rings soldered to the rotor bars of 10-hp. alternating-current induction motors used to drive our freight elevators. The soldering was done in a local electrical repair shop, but as the price of labor and material went up so did the bills for repairs. It was decided to have the bars welded to the end rings if possible, but we were informed that this could not be done as the high temperature due to welding would destroy the rotor slot insulation. However, after some consideration of the matter it was decided to put the



ROTOR PLACED IN CAN OF WATER

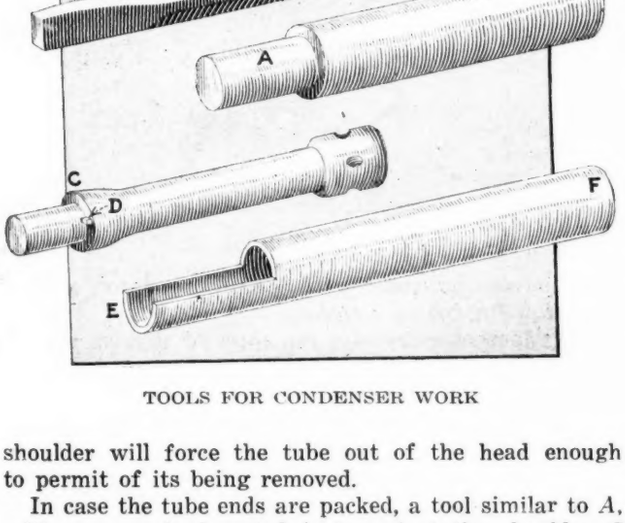
rotor into a tin can, made for the purpose and filled with water, as shown in the figure. The can was filled until the water came just above the rotor's slot insulation, leaving the end of the bars and end ring to be welded above the water. The bars were welded to the rings with Tobin bronze, the rotor dried out and balanced and the machine put back into service. The first machine that had its rotor conductors welded has been driving a freight elevator for about five months without any sign of trouble. The cost of welding was about one-third that of resoldering. THOMAS SHEEHAN.

Springfield, Mass.

Handy Tools for Surface Condenser Work

Considerable time can be saved when removing, replacing and repacking surface condenser tubes if the proper tools are utilized. The tool first used will depend upon whether the tubes are expanded into the tube head or whether the packing is held in place by the ordinary threaded and slotted ferrule. If expanded into the head, the first tool needed will be an ordinary rectangular ended calking tool with which the slight flange or bell of the tube can be turned in. This tool can be easily forged from a piece of hexagon tool steel as shown at the top of the illustration, the working end being about one-quarter inch thick by three-quarters inch wide and length of an ordinary chisel.

The second tool, called the backing-out tool, is made from a piece of cold-rolled steel, the diameter being the same as the outside diameter of the tubes. One end is turned down for two or three inches to a diameter slightly less than the inside diameter of the tube, as shown at *A*. When the tool is driven into the tube, the



TOOLS FOR CONDENSER WORK

shoulder will force the tube out of the head enough to permit of its being removed.

In case the tube ends are packed, a tool similar to *A*, with a crosspin inserted just against the shoulder *C* and made to fit the slot in the ferrule, is used, the diameter of the smaller end being slightly less than the inside diameter of the tube, and the diameter at *D* back of the shoulder the same as the outside diameter of the ferrule. The head end can be made hexagonal so that a wrench can be used on it, or it can be drilled as shown with two holes at right angles through which a bar can be inserted for turning it to back out and screw in the ferrules.

In replacing the tubes it is sometimes necessary, if they are of an unusual length for this diameter, to insert a rod into the tube of slightly greater length than the tube in order to feed it through the baffle plates and into the opposite head. In case the end of the tube sags down, an ordinary piece of round iron can be slipped through the tube sheet and into the tube, permitting the feeding of the tube into the tube sheet.

The next operation is to expand the tubes into the sheet with a regular expander for this purpose, or in the absence of one, the tubes can be swaged into place with a bluntly tapered tool that will expand the end of the tube while some one holds a backing-out tool against the other end.

If the tubes are packed in with either corset lace or fiber ring, a packing tool is made by taking a piece of the tubes in use and grinding away one-half of it for a length sufficient to reach the bottom of the stuffing-box and then expanding the remaining half to a circumference slightly greater than the tube but just so it will go into the packing space.

The bottom illustration shows the manner in which the tube is ground away so that *E* presents a semicircular end which will enable one to pack the tube ends in a rapid and satisfactory manner by driving on the end *F* lightly with a hammer. After sufficient packing is in, the packing wrench *C* is brought into use and the ferrule is tightened up, ready for a test to see whether a tight job has been made.

There are two methods of making this test. One way, which usually requires considerable time, is to fill the steam space with water and look for drips from the tube ends. A more speedy way is to start the air pump, which will exhaust the air from the steam space and at the same time cause air to be sucked in through any ruptured tube or leaky packing to the extent that it can be easily heard and traced by simply running the hand flatwise over the tube ends; or if there should be too much noise from the outside, by using a candle over the ends of the suspected tubes, the flame of the candle being drawn in wherever there is an air leak of any importance.

F. M. STERLING.

Canton, Ohio.

Testing Boilers for Air Leakage

Practically every up-to-date boiler plant has a flue-gas analysis instrument. In most cases this instrument is used only as a check on the fireman, to see if he is giving proper attention to his fires. An instrument of the portable type may be made valuable in finding out whether a boiler setting is air-tight, the amount of the leakage and the approximate position of the leaks if there are any. This may be done by taking quick CO_2 readings in different parts of the setting. If the setting is tight, there should be no difference in the reading between any two points.

First readings should be taken between the first pass and the damper. If no drop or only a slight drop is obtained, the setting is air tight and no further search is necessary. Care should be taken that the reading in the first pass is taken far enough along the pass to have proper combustion and thorough mixing of the gases.

If a drop is obtained, readings are taken between passes until the drop is located between two points. It may then be exactly located by means of a torch. If the search for leaks can be narrowed down to a small part of the setting, a much better job can be done in stopping them. Moreover, there is no guesswork about when they are stopped up. A few readings will tell whether they are stopped or not.

My experience has been that the losses due to small air leaks are not appreciated. Separately they may not be large, but the total may be considerable. The method I have described, not original by any means, but not used as much as it should be, will tell just how serious the air leaks are; and when repairs are made and thought to be complete, it will tell whether any holes have been overlooked.

W. D. TAYLOR.

Connellsville, Penn.

Slow Engine Speed and Condensation

One morning it was noticed that the blower engine driving the boiler forced-draft fan failed to come up to speed when the steam dropped a little. An examination of the engine failed to disclose anything amiss until the cylinder head was removed, when it was discovered that the piston had no rings, but two small pieces were found. This engine was located in the boiler room and was under the care of the firemen, but on making inquiries nobody knew anything about the engine getting a slug of water.

A few days after new rings had been put in, the chief was standing by the engine, which was running slowly, when a sudden demand for steam caused it to speed up quickly and a sharp clicking in the cylinder, indicating water, caused him to open the drain-cocks. The fireman said that this frequently happened, and then the chief knew that the cause of broken rings was water.

When the engine was running slowly, condensation formed in the steam line and a sudden demand for steam would carry it into the engine cylinder.

Boston, Mass. FRANKLAND CHENEY.

The Selk Safety Stop

Several years ago when I took charge of the steam plant of the Brooks-Scanlon Lumber Co., Bend, Ore., as chief engineer, I found that the 26 x 42-in. Corliss engine with an 18-ft. flywheel was not provided with a safety stop, so I invented the stop shown in Figs. 1 and 2. The arrangement worked so well and was so sensitive that I applied for a patent, which is now pending.

The working arrangement is such that when the throttle is open, the latch lever is pushed toward the

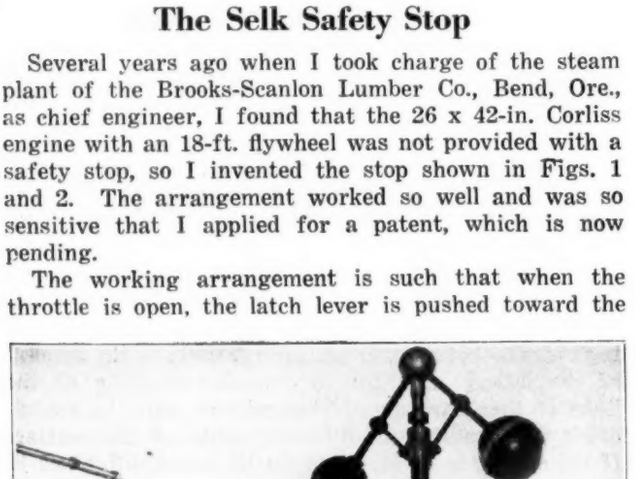


FIG. 1. WEIGHTS IN TRIPPED POSITION

governor, as shown in Fig. 1, where the weights are down. When the throttle is closed, the latch rod is drawn back toward the throttle valve by a curved spring, a collar on the throttle-valve stem moving inward as the valve is closed, which allows the spring to draw the latch rod back so that the collar on the upper gag-pot stem will pass the end of the latch or short trip lever without tripping the weights.

In case anything should happen to the governor when the engine is running, the governor balls will drop. This action will trip the latch and the two weights will fall from a vertical position, Fig. 2, to a horizontal position, Fig. 1, and in so doing push the upper gag-pot stem upward to its limit and spread the governor balls out as if in full motion, only more so. This action will move the two trip cams on the engine steam valves to such a degree that the crab claws will not catch there

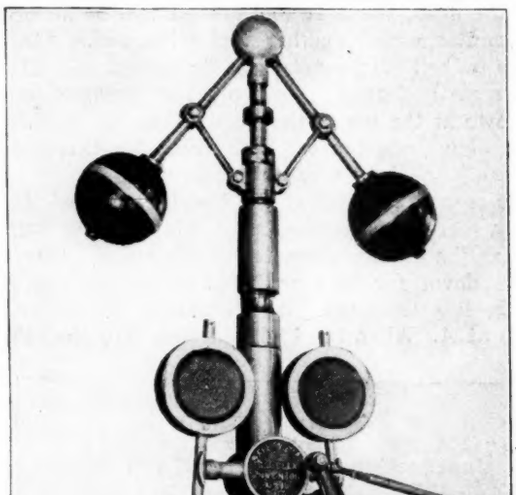


FIG. 2. WEIGHTS SET FOR TRIPPING

by allowing the steam valves to remain closed, and the engine will come to a stop.

It is then necessary for the operator to push the two weights back to a vertical position before steam can be admitted to the engine and the arrangement is again in operation. This is a reliable safety stop and has been in use two years and during that time it has been thoroughly tested. It can be electrically operated from any distance. G. J. SELK.

Bend, Ore.

Owners Should Supply Instruments

When shall we have the operating engineer strongly advised to carry around with him a CO_2 recorder, a draft gage, a pyrometer, a few thermometers, etc.? Surely, instruments enumerated are as much to be desired as an engine indicator, and any of them is much cheaper than the latter instrument.

Candidly, I am of the opinion that if the owner of a plant cannot provide an engine indicator where reciprocating engines are in operation, then no sympathy should be extended to him if his fuel bill is high. I consider that it is not up to the operating engineer to buy such an expensive instrument as an indicator. Educate the owners, you engine builders, boiler manufacturers and power-plant designers, and impress on them the necessity of having the necessary instruments in the plant. J. B. TAIT.

New Westminster, B. C., Canada.

No responsibility should be placed on a man until he has confidence and knowledge to do the work.

Inquiries of General Interest

Testing Safety-Valve Capacity—What test can be made for determining whether a safety valve is large enough for a boiler? D. M.

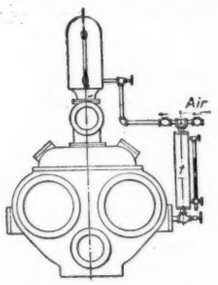
To be of sufficient capacity, a safety valve must be capable of relieving the boiler of steam at such a rate that the boiler pressure cannot be raised above the safe working pressure when the firing is forced as much as possible, and there is no steam escaping except through the safety valve. Such a capacity test should be made by gradually increasing the rate of firing, but should not be made without having means available that are known to be reliable for immediately checking the fire and also for relieving the boiler of steam, in case there is any increase of pressure above the safe working pressure for the boiler.

Employment of Motor or Utilization of Exhaust—When 50 hp. is required for driving a paper-making machine, would it be more economical to drive with an electric motor and supply steam for drying the paper, or to drive with an engine and use the exhaust for drying and for heating water? J. J. H.

The question hinges mainly on the cost of electric power. Under ordinary conditions, after the live steam required by the engine is converted into exhaust, it may be utilized for performing 65 per cent. as much heating as if used directly in the form of live steam. Hence, with an electric motor there would be about two-thirds as much steam used, and for superior economy in use of a motor the cost of electric power delivered to the paper machine would have to be less than one-third the cost of live steam required to be delivered to the engine.

Loss of Air from Pump Air Chamber—What causes loss of air from the air chamber of a pump, and how may it be remedied? W. T.

Water under atmospheric conditions contains about 2 per cent. air in solution and when in contact with air at higher pressure, more air is absorbed by the water. Consequently, the volume of air in an air chamber that is connected on the pressure side of a pump becomes reduced. The figure illustrates an air-charging device that utilizes the varying pressure in one of the pump chambers to compress air into the air chamber. A vertical tube t is attached to the side of the pump body and is in communication with the inside of one of the pump chambers. The upper end carries two check valves, one for suction and one for discharge, communicating with the air chamber. The pulsations in the pump chamber produce similar pulsations in the tube, thus forming an effective air compressor, without danger of the air entering the pump chamber.



Water Delivered by 6-In. Pipe Line—With 25 ft head what quantity of water can be delivered through a 6-in. cast-iron pipe 1000 ft. long? T. J. C.

The highest rate of flow will be obtained when the whole head is absorbed in overcoming friction at the entrance and pipe friction and in producing the velocity with delivery from the discharge end at atmospheric pressure. With 25 ft. head available a clean 6-in. cast-iron pipe line 1000 ft. long, with delivery at atmospheric pressure, would discharge about 500 gal. per min. For delivery of 400 gal. per min. the loss of head would be about 15 ft., leaving a discharge head of 10 ft.; for 300 gal. a loss of head of about 8.5 and discharge head of 16.5 ft.; for 200 gal. a loss of head of about 4 ft. with a discharge head of 21 ft.; and for 100 gal. per min. a loss of head of about 1 ft. with a discharge head of 24 ft.

Current per Terminal in a Three-Phase Circuit—Each of the lamps in Fig. 1 takes 5 amperes, which is in phase with the voltage applied to it. What is the value of the current flowing in each line wire? The generator is connected in star and gives a correct three-phase voltage. E. C. B.

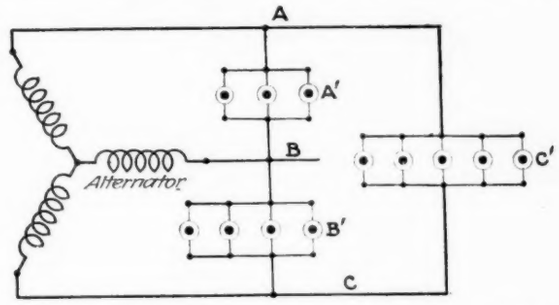


FIG. 1. DIAGRAM OF ALTERNATOR AND LOADS

Since each lamp takes 5 amperes, load A' will take $3 \times 5 = 15$ amperes, load B', $4 \times 5 = 20$ amperes and load C', $5 \times 5 = 25$ amperes. The different currents are in step with the voltage across their respective circuits, therefore they are 120 deg. apart and may be shown vectorially as in Fig. 2. The current in line A is the vectorial sum of loads A' and C', that in line B the vectorial sum of loads A' and B' and that in line C the vectorial sum of loads B' and C', flowing toward or away from the respective conductors. Then by combining the loads in Fig. 2 vectorially, as shown in Fig. 3, the resultants A, B and C will represent

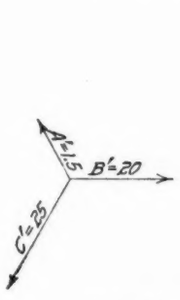


FIG. 2. VECTOR DIAGRAM OF LOADS, FIG. 1

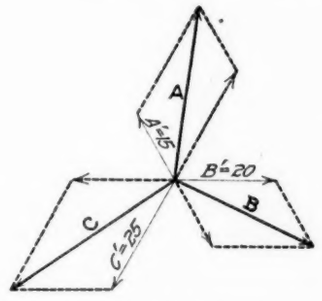


FIG. 3. VECTOR DIAGRAM OF CURRENT IN WIRES A, B AND C, FIG. 1

to scale, respectively, the value of the current in A, B and C, Fig. 1. In Fig. 3

$$A = \sqrt{(A')^2 + (C')^2 + 2A'C' \cos 60 \text{ deg.}}$$

$$B = \sqrt{(A')^2 + (B')^2 + 2A'B' \cos 60 \text{ deg.}}$$

$$\text{and } C = \sqrt{(B')^2 + (C')^2 + 2B'C' \cos 60 \text{ deg.}}$$

As cos 60 deg. = 0.5, then,

$$A = \sqrt{15^2 + 25^2 + 2 \times 15 \times 25 \times 0.5} = 35 \text{ amperes}$$

$$B = \sqrt{15^2 + 20^2 + 2 \times 15 \times 20 \times 0.5} = 30.4 \text{ amperes}$$

$$C = \sqrt{20^2 + 25^2 + 2 \times 20 \times 25 \times 0.5} = 39 \text{ amperes}$$

That is, the current in A conductor, Fig. 1, is 35 amperes, in B conductor 30.4 amperes and in C conductor 39 amperes.

Factors in Obtaining Maximum Output from Hydro-Electric Plants*

By FRED A. ALLNER
General Superintendent, Pennsylvania Water and Power Company, Baltimore, Md.

THE following refers to a 100,000 hp. low-head plant, located on a river, the latter having a protracted low-flow period interrupted occasionally by freshets. By means of high-tension transmission lines the plant is tied in with several steam stations of about equal total capacity. During the high-flow season the water-power plant operates at high load factor, running wide open for about sixteen hours. The steam plants carry the peaks of the load. During the low-flow season the steam plants operate at nearly 100 per cent. load factor, while the water-power plant carries the peaks.

High-Flow Season — When the river flow exceeds the power-house draft, maximum output of the hydraulic plant is obtained by (1) Operating main units in wide-open condition for the maximum possible number of hours; (2) adusting gate-operating mechanism in such manner that wide-open condition of operating piston actually produces maximum clear opening of guide vanes; (3) using high-flow flashboards; (4) carrying a minimum of wattless current at the water-power plant; (5) operating a minimum of alternating-current-driven excitation and station auxiliary apparatus during the wide-open hours; (6) improving ventilation by blowers and proper directing of air to hot parts of generators, if hydraulic output exceeds the electrical rating of some units; (7) careful inspection and preventive maintenance of all apparatus that when out of service may reduce station output; (8) organizing necessary low-flow overhauling work so that it can be completed in a minimum of time.

Low-Flow Season — When the river flow is less than power-house draft the maximum hydro-electric energy for a given river flow is obtained by (1) Distributing total station load on smallest number of turbines consistent with load conditions, so as to cause a minimum of water draft through the power house for a given load at any time; (2) holding forebay at highest possible elevation; (3) efficient use of low-flow flashboards; (4) transferring wattless current to steam units and synchronous receiving apparatus, if same can be carried there at a lower over-all loss; (5) distributing excitation load between waterwheel- and motor-driven units for minimum water consumption; (6) reducing station power requirements for auxiliaries to a minimum consistent with safety.

A number of the high- and low-flow features enumerated had been practiced for several years at the plant under discussion, but found a more thorough application during the war period through more stringent follow-up methods.

Some other features were introduced under wartime pressure that promise useful application in the regular operation of the plant.

Knowledge of Individual Customers' Loads Essential

Knowledge of the loads of the individual customers, and of the operating characteristics of those steam plants which run in parallel, is essential. Governor adjustments require to be worked out for parallel operating conditions of the various plants, so as to reduce as far as possible the number of occasions when load fluctuations are taken up by the hydraulic plant instead of by the steam plants, during hours when total system load exceeds hydraulic capacity. A daily record showing the amount and specific causes of "Energy Wasted" due to hydraulic plant not being loaded up full, while steam plants carry an undue portion of the load, offers a useful follow-up method for the operating force. These losses may aggregate 50,000 kw-hr. per day (for about 2,000,000 kw-hr. total system load) and even exceed this figure if parallel operation between the plants is not closely watched.

Owing to the cumulative effort of lost motion in gate-operating mechanism, it frequently occurs that wide-open condition of operating piston does not actually produce maximum clear opening of guide vanes. Periodical checks should be made on the output of individual units, and if reductions in output are found, they should be traced to definite causes.

On a certain 10,000-kw. unit, just before the time for overhauling had arrived, this loss of output was about 250 kw., and even on units in fair condition it may easily reach 100 kw. A standard steam indicator mounted on the operating engine is useful for such investigations, as it permits the reading of lost motion in the mechanism and of operating pressure required for moving gates in different positions, etc. If guide vanes and other parts of operating mechanism were originally adjusted correctly, excessive lost motion may be compensated for by increasing the piston stroke without taking the unit out of service. If no provision is made for this in the design, it may be possible in many cases to obtain the increased stroke by substituting a shorter piston head, which can be inserted during off-peak hours.

Increase of output through the use of high-flow flashboards may be quite appreciable. Although using a board of only about half the height of the low-flow flashboards, this gain in output may, under certain conditions, equal or exceed the gain from the low-flow boards.

Reactive Current an Undesirable Element

For a given system load the reactive or wattless current is an undesirable element of the power load that must be furnished by the generating stations, together with the power current. In a combined steam and hydraulic system where the hydraulic plant is usually some distance away from the point of consumption of energy, it will generally be found more economical to let the steam units and some of the synchronous receiving apparatus carry as much of the reactive current as possible. The transmission of undue wattless current through the high-tension lines, step-up and step-down transformers, will increase considerably the metered reactive watts, as carried at the hydraulic station. Transmission losses will increase, and in addition, in order to maintain normal voltage at the point of delivery, a high bus voltage will be necessary at the hydraulic plant, such higher bus voltage carrying with it greater excitation and core losses in the generators.

Installation of reactive wattmeters on the totalizing meter-bus of hydraulic and steam stations and at the points of power delivery at the receiving station is necessary for the study of such load conditions and for the "displacing of reactive load" in regular operation.

Hydraulic stations that do not have a rigid system of excitation such as individual motor-generator sets or exciters directly connected to the turbine shaft offer a certain flexibility in the distribution of excitation and station auxiliary load that may be used to advantage for obtaining maximum output. A plant with partly waterwheel-driven and partly alternating-current-motor-driven exciters, and an emergency storage battery operating in parallel, should, during ample flow periods, obtain as much of the excitation and auxiliary power as possible from the waterwheel-driven exciters during the hours when the main units are operating with gates wide open. Intermittent station auxiliaries should be operated mostly during the off-peak hours, between midnight and morning peak.

The use of high-flow flashboards or other special expedients for securing higher operating head may have the effect of increasing the hydraulic output of turbines beyond the electrical rating of the generators. The generator ratings may then be raised by making provisions for bet-

*From the 1919 Report, Prime Movers Committee, National Electric Light Association.

ter cooling them. In such cases reliable hot-spot temperature indicators are almost indispensable. If different types of generator units are used in the plant, some increased output therefrom may be obtained by running the lower-rated generators at high power factor and throwing the bulk of the low-power-factor generation upon the units having higher ratings. In some cases even this remedy is insufficient, and it may pay to provide individual blowers to direct air to the hot parts of the generators or arrange the whole plant for a central ventilating system with large blower units.

Careful inspection of all apparatus at regular intervals is one of the chief requirements of preventive maintenance, as contrasted with mere repairing of breakdowns. This is a large field for the practical maintenance engineer in every hydro-electric plant, although it may show its value only in the course of several years.

During the hours between midnight and morning peak and over the Sunday recess it should be possible in many plants to carry out all the inspection work of the interior of turbines if arrangements are worked out for proper organization of crew and time-saving inspection facilities.

Certain overhauling work that is necessary, due to wear of vital parts, should be completed within a minimum time, so as to keep the unit out of service as short a time as possible. Foreknowledge of the nature of the work, providing in advance the spare parts for renewal and scheduling of the work in advance have made it possible to reduce the time that was originally used for such work to nearly half in this station. On several occasions a quickly approaching rain freshet in the midst of the low-flow season has been taken advantage of by putting quickly into service a unit that was undergoing maintenance overhauling. A week's delay in each case would have entailed the loss of opportunities to utilize the flow from the freshet In one case, for example, it meant an increase of 180,000 kw-hr. per day in delivered energy.

At the same plant a bonus system for the hydraulic-maintenance force has been in use for two years, whereby the crew receives extra pay for each day that it is able to shorten the actual time that a double runner unit is out of service for major overhauling, as compared with the scheduled time.

Under low-flow conditions the principal aim of the hydraulic plant is to produce a maximum of kilowatt hours from a given river flow.

Best Load Distribution

The joint operation of the hydraulic and steam plants under discussion required that "best load distribution" should always be understood to mean not only best water economy, but also best combined water and fuel economy. The steam plants, during the low-flow period, are operated as nearly as possible to 100 per cent. load factor, using at first their most efficient units and then placing the additional and less economical equipment into service as the river flow drops lower. The problem of best combined economy is, however, largely a problem of hydraulic economy.

Occasionally, it is necessary to deviate from this rule, because of temporary shortage of fuel or tie-up of coal transportation or handling facilities at one or at both of the principal steam plants.

Of the eight main units of this hydraulic plant the first five have double runners of identical type, two more recent ones have runners of somewhat different characteristics, and the last unit is of a single-runner high-efficiency type. A table has been computed from the various turbine output-discharge curves to assist the operators in distributing the load among the units so as to secure best efficiency.

Holding the forebay at the highest possible elevation is of considerable moment in the operation of a low-head plant. This is quite apparent if it is realized that a faulty estimate of flow or load, or both, on, say, a fifty-foot head plant, with an average connected load of over 2,000,000 kw.hr. per day, but with a storage capacity of only 100,000 kw.-hr. per ft. draw-down of forebay pond, would entail a loss of 1 per cent. of the following day's hydraulic output, if the forebay level when entering upon the morning peak is 0.5 ft. lower than the proper level. This difference in forebay level, however, represents only 2½ per cent. of the system load. It is quite apparent, therefore, that an accurate manipulation of forebay is possible only by a thorough understanding of system local conditions, foreknowledge of flow and closer coöperation with the steam plants.

Flashboards, as a rule, are treated with less engineering care than other station apparatus that is looked upon for yielding the same amount of energy in the daily operation. Leakage between the concrete sill of dam and boards, losses in the vertical and horizontal joints between boards, effect of wave action on the loosening of tightening devices, etc., can reduce the effective gain from flashboards to a considerable extent. On the other hand, proper equipment and organization of crew for tightening the boards, erecting them quickly after a freshet, or removing them intact at the approach of a higher river stage can increase the station output appreciably. The net gain from flashboards in the plant described varied, of course, with the flow, but for an average low-flow stage of 10,000 cu.ft. per sec. and a head of 55 ft., it could be made to exceed 60,000 kw.-hr. per day. Most economical distribution of a given excitation and plant auxiliary load between waterwheel-driven and alternating-current-driven exciters is obtained by the use of output-discharge curves.

Although station auxiliaries, exclusive of excitation, consume only about 1 per cent. of the high-flow station output, it is possible to accomplish a measurable economy by studying the load requirements of the individual apparatus. During extreme low-flow stages the above percentage may double or treble, since certain station auxiliaries are necessary, regardless of amount of station energy output.

In some cases the original layout of a hydraulic plant does not provide for individual watt-hour meters or other instruments to measure the power of the auxiliaries.

Lubrication Problems*

Among the lubricating problems awaiting solution are those relating to the behavior of lubricants at high pressures and temperatures. It has been the common experience of operators that organic oils—for example, lard oil and sperm oil—are much more effective than mineral oils of similar viscosity. The reasons for this are as yet more or less obscure.

It has long been known that high pressure produces measurable changes in the viscosity of certain fluids. It has been found by experiment that lard oil and mineral oil of about the same viscosity at atmospheric pressures showed great increase in viscosity under pressures of 200 to 500 atmospheres. Likewise it is well known that all lubricants decrease in viscosity with an increase in temperature. Viscosity measurements are rarely made at temperatures above 100 deg. C., which is much lower than that reached in severe service.

What experiments have thus far been conducted to show the adhesive qualities of lubricants under these conditions show no slipping at the boundary surface between lubricant and the solid surfaces at moderate rates of shear in the lubricants. Albert Kingsley has experimented with a device consisting of a slightly tapered plug rotating in a ring closely fitted by grinding. The thickness of the oil film was determined by micrometric end adjustment of the plug. With films as thin as 0.000025 in. and rates of shear up to 261,000 radii per second, at atmospheric pressure and temperature, there were no indications of slip. If slipping should take place, then the question would come up whether the results depend upon the nature of the bearing metals.

Lubricants that exhibit oiliness to a marked degree may contain in solution solids which tend to concentrate at the boundary surfaces. This increases the viscosity at the surface and therefore increases the lubricating value at high pressure. There is no direct evidence on this point except in the case of soap dissolved in the water used in hydraulic cylinders. The soap concentrates upon the metal surfaces, forming a good lubricating film.

*Report of sub-committee on lubrication for representation at the Spring Meeting, Detroit, Mich., of the American Society of Mechanical Engineers, 29 West 39th St., New York.

The Power-Plant Cost Sheet*

By Arthur E. Huntington

Cost of power enters into the cost of manufacturing in largely varying percentages, ranging from only a small percentage on some products up to approximately 33⅓ per cent. of an electric light and power business. In the average manufacturing plant the ratio of cost of power to the total cost is from 7 to 12 per cent. Be that percentage great or small, it is the duty of each engineer to know not only the cost of his power, but to know its relation to the total cost of manufacturing. Many a good engineer has worked for years feeling that his services were not appreciated and that he was not getting the money that was due him—and he does not. Such a fellow has been operating a power house only and has failed to make himself a part of the balance sheet of the concern. It is important that the engineer finds out just what his part of the work is and just how it fits into the whole scheme. It is then up to him to stake out his claim on the balance sheet, defend his rights by making the manager feel that he is individually responsible for from 10 to 20 per cent. of the business and that he can be trusted with it.

Customer Should Have Data Sheet

Any man going after a power customer ought to have first of all a data sheet showing the nature of the load, and including the following items: Maximum load, load factor, power factor on alternating-current circuits, annual load, data as to how the load fits in with other loads, reserve capacity required and whether the reserve capacity already in use can be utilized, with a large space left for remarks, as conditions are continually changing.

It is seldom that a large amount of power can be added to any plant without some additional investment. A data sheet should show just what each of these investment items should be. They may be divided under (1) Power plant, (2) distributing system, (3) going value, (4) other values.

Under the first item the plant capacity required to handle the load should be noted. In large plants quite frequently some transforming devices must be taken into account.

Under the distributing system the investment should include not only the new construction necessary to handle the business, but also a just allowance for joint use made of equipment already in existence. A capital charge against each power customer should be made, even though capacity already available is being used. On each extension the proper procedure is to figure clear back to the cash drawer.

Going value is an item to be considered. Unquestionably, a plant with an established business is worth more than the same plant with no business. All courts and commissions grant such a value, but few of them agree just how much it is or how it should be figured. One commission ruled that the going value was an amount of money equal to interest and depreciation on that part of the plant that is not in use during the development period. In other words, if a plant costs $100,000 and it takes two years to develop the load, if development were uniform the going value would be the carrying charges on a $100,000 investment for one year, or about $15,000. This would be a fair way to figure it were it not for the fact that a plant having an energetic manager would get less going value than a plant with a poor manager. Evidently, if a high going value were desired, it could be obtained by being slow in developing the property.

Others prefer to define going value as the amount of money necessary to develop the business on a certain property and get it onto the line. For present purposes it will be sufficient to say that going value represents the difference between the value of the property as a going concern with the business attached to it, as against the same property without the business. In figuring the investment, account should be taken of the cash required to do business, which includes money tied up in supplies as well as many other items. In a power company this amount usually represents 90 to 100 days' income, and quite frequently intangible assets represent 30 per cent. of the total capital charge. In a manufacturing concern it represents the period that elapses between the time the power bill is paid and the time when the product is sold and the money is in the cash drawer. As an interested party in the balance sheet, the engineer has a right to know for just how long the money which his department costs is tied up.

Determining the Charges That Should Be Made

With the value of all the property established, the next step is to determine the various charges that should be made. Some of these are nearly constant, while others are variable. Under fixed charges, take interest as the first item. Frequently, good business men refuse to consider this item and try to dismiss the subject by saying that the plant is theirs and all paid for and that there is no interest, although the money is in the business and was put there to bring a return. The interest charge should be based on all that it costs to get money into the cash drawer to do business with. The tendency is to figure such items too low.

Insurance, taxes, repairs and upkeep usually have some place on the company's books and are easy to get.

As to depreciation, it makes little difference whether the straight-line, sinking-fund or compound-interest method is used. The main thing is to be sure and set aside enough. No engineer should permit his company to set aside less money than will maintain the plant at all times at about 85 per cent. of standard, or in other words, in a condition that would make it equal to 85 per cent. of a new plant. Without figuring it out exactly, it is fair to assume that the average plant that sets aside 5 per cent. for depreciation could be maintained at an 85 per cent. standard; 4½ per cent. represents about 80 per cent. standard, and 4 per cent. a 70 per cent. standard. This item is sometimes figured at 3 per cent. because some engine that the engineer knows of has been running for a long period of years, without considering that the engine might be obsolete and require an excessive amount of steam. The best method is to figure depreciation on each item separately—engines, boilers, pumps, condensers, belts, shafting, generators, etc. This is much better than taking some fixed percentage and then spreading it over the entire plant. In an electric-light plant these items of interest, taxes, depreciation and upkeep, that come under fixed charges, usually figure about 15 per cent. of the gross value of the tangible assets. For the intangible value 8 per cent. is about the right figure to allow.

Cost of Operation Must Be Included

To the preceding must be added the cost of operation, including labor, coal, water, supplies and incidentals. With this part of the cost sheet the engineer is usually familiar. The main thing is to know what it cost to deliver a kilowatt-hour at the point of use and not on the indicator or switchboard readings. In a test made recently on a certain plant the losses were shown to be more than 66 per cent. of the total power generated. The power company must charge to the cost of production, sales and legal expense, administration, insurance, collection, etc. If all these items in their true value are figured, the engineer will have somewhere near the true cost of power and can show to the management what proportion of the business he represents. If he is a man who takes into the cost of power just such items as coal, labor and repairs, he is not an engineer at all, but a throttle twister. If he knows the costs and makes himself an integral part of the balance sheet, he is a real engineer.

Some men in charge of power plants are fine mechanics, but never get beyond the stage of throttle twisters. Their power houses are always ready, their engines run smoothly and show a fine card whenever the indicator is applied. They really make power at a low cost, yet the management does not value such men highly, because they are not considered a part of the company. They are viewed more as high-class laborers who do not produce anything that is figured into the cost of production more than in a general way. On the books there is a place where power costs are kept, but the engineer never sees it. That part of the book

*Abstract of paper read before the Iowa State Association N. A. S. E., Marshalltown, June 13, 1919.

is presided over by a $10-a-week bookkeeper. How many engineers are willing to have their standing with the company valued by a clerk in this way?

An engineer should be a man of clean personal habits, who has an ambition to be somebody both in his community and with the company. He should be a mechanic and understand how to handle men; he must be able to figure his costs intelligently and to apply that knowledge diligently and continually. He should know and impress upon the management the part that the engine room really plays on the balance sheet and should have at least a working knowledge of business methods. He may not be proficient in all these items, but with a little effort he can become familiar with them, and when he is he can call himself a real engineer.

Progress in Water Power*

Increasing attention is being given to details of design affecting ease of operation of the turbine, and ease of conducting maintenance work on it. Accessibility of parts, better provision for thorough lubrication, removal of gate-rigging mechanism from exposure to the corrosion elements of the water, provision for adjusting pinch-fits of gates, and taking up backlash in the operating mechanism are all in themselves minor factors of improvement, but of importance in the aggregate. Troubles formerly encountered from the use of oil in closed governor system have been done away with by the use of the open reservoir system. Where water is used as an operating fluid in the governor system, the corrosion resulting therefrom and the attendant difficulties are being met in various ways at different plants, as, for example, by the neutralization of the governor fluid with barium-hydrate treatment combined with the use of so-called soluble oil, or of potassium bichromate. Cooling of lubricating oil from thrust bearings seems to be giving some difficulty in the hot-weather climate. It is reported that better results are obtained by using open-air cooling coils, on which the water is sprayed and the cooling effect obtained by evaporation, as compared with the tank coil cooler.

The rapid rusting of intake-screen equipment in corrosive river water is continuing to give trouble in certain plants, and no special paint seems to have been found to afford protection for more than a few years. A very heavy red-lead covering seems to be about as satisfactory a coating as any, and the expedient adopted in one plant is to withdraw and paint a certain number of rack sections each year, the cost of painting being kept down by the use of spray apparatus. The screens are previously cleaned up by sandblast.

Interest is being increasingly aroused in the development of smaller water-power plants consisting of low-capacity remote-control stations connected together to assist in using one or more plants of fairly large size in the master stations.

There is a growing realization of the importance of not only designing a hydro-electric plant for high efficiency, but of providing in its design for the necessary equipment to enable its operating efficiency to be checked and maintained. The building in of piezometer equipment in each turbine intake is recommended, in the case of new layouts, whereby after a calibration of one intake by appropriate water-measuring arrangement, a continuous periodical checking up of each individual unit may be easily obtained, and thus the degree of accuracy of the hydraulic operation of the station ascertained.

The Johnson type of valve is finding increasing use in water-power developments, being now made in sizes as large as 144 in. diameter and valves of 36 in. diameter are being used under heads of 1000 ft. A detailed description of this valve is found in the 1913 report of this committee.

The committee is in receipt of statements from the following manufacturers, covering developments during the year:

The Allis-Chalmers Manufacturing Co. reports the following installations which are given in chronological order: Tallahassee Power Co., Nadin, N. C. Three units, each of 31,000 hp., 180 ft. head. In operation over one year at the present writing. Tallahassee Power Co., Cheoah development, four units, 27,000 hp., 188 ft. head, completely erected. Hydraulic Power Co., Niagara Falls, now Niagara Falls Power Co., three units, 37,500 hp., 214 ft. head. Erection of machinery just started. Hydro-Electric Power Commission of Ontario, Chippewa development, two units, 52,500 hp., 320 ft. head. Contract awarded.

Probably the most novel improvement in connection with draft tubes is found in the hydraucone, which has been applied successfully to quite a variety of installations where operating data are available. This device has been installed in connection with the following plants, on which operating data have become available during the past year. Berlin Mills Co., Shelburn plant, two units, 1200 hp., 17 ft. head. Detroit Edison Co., Geddes plant, 575 hp. Manchester Traction, Light and Power Co., two units, 2175 hp., 63 ft. head. Sheboygan Electric Light and Power Co., two horizontal units, 750 hp., 19 ft. head. Hydraulic Power Co., one unit, 37,500 hp., 214 ft. head.

William Cramp & Sons Ship and Engine Building Co. report: In 1918 there was considerably more activity than in the previous year, the aggregate horsepower contracted for by our company being nearly three times greater than in 1917. One-fourth of the units contracted for during 1918 are for extensions to existing plants.

There was a marked tendency toward the installation of high-powered units, the average size per unit being 17,600 hp. The 37,500-hp. turbine now under construction for the Niagara Falls Power Co., when completed, will be the most powerful turbine in the world. For the turbines contracted for by our company during 1918 the designed head ranges from 130 to 475 feet.

Pelton waterwheels in units as large as 15,000 hp. on a single Pelton or impulse turbine runner and for a head of 2000 ft. have been constructed.

The Wellman-Seaver-Morgan Co. has given considerable study to low-capacity remote-control plants. One centrally located plant of fairly large size can be used as the master station, and several other low-head plants within a radius of 15 or 20 miles may be operated from this plant without attendants whatever, except a man to drop around occasionally. This is merely a necessary condition to make a plant of 100 to 500 hp. a paying proposition.

The largest proposition being developed at present is the Niagara development on the Canadian side, for the Hydro-Electric Commission of Ontario. We have been awarded the contract for the first two units. Each turbine will develop 52,500 hp. at point of maximum efficiency, and about 60,000 hp. at full gate open.

*From the report of the Prime Movers Committee of the National Electric Light Association, 1919.

House Passes Water-Power Bill

The House of Representatives has now passed the water-power bill. The bill is substantially the same as the measure which was passed by the House of Representatives at the last session of Congress. No important amendments were made. The measure is now before the Commerce Committee of the Senate, and will be taken up by a subcommittee of that body shortly after Aug. 1, when Senator Jones of Washington, who is the chairman of the committee, is expected to return from a visit he is now making to Seattle. The other members of the subcommittees who will have jurisdiction over the bill for the time being are Senators Nelson, Lenroot, Bankhead and Fletcher. Friends of water-power legislation in Washington hope for the early passage of the bill by the Senate, but in legislative circles at the Capitol it is well understood that the question of foreign affairs relating to the Peace Treaty and League of Nations will have an important effect upon the early passage of any legislation.

England is preparing to provide herself with cheap and abundant electricity for heating, lighting and manufacturing purposes at an initial cost of approximately $100,000,000. The plan, which is now before Parliament, provides for placing the country on an electrical basis. Water-power is to be extensively used.

Methods of Increasing Boiler-Room Efficiency*

By D. S. JACOBUS
Advisory Engineer, Babcock and Wilcox Company

MY REMARKS will be limited to that part of the general problem of fuel saving that is met in the boiler room. More is often to be lost or gained in the operation of the boiler room than in any other part of a power plant. To secure efficiency and capacity we all know that the following features must be watched after: The surfaces of the boiler must be clean inside and out and the gas passages and flues must be free and unrestricted from the deposit of soot or ashes; the baffles and settings must be reasonably free from leakage; the fuel must be properly fired.

To secure the best efficiency, the fuel or any combustible elements distilled from the fuel must be completely burned within the furnace chamber. Again, the combustion must be such that the gases that pass from the furnace are uniform in composition; that is, some of the gases must not contain a considerable amount of excess air and others possibly a deficiency of air, thus leading to what is termed a laneing action. If the gases are burned entirely within the furnace chamber, the entire surface of the boiler is effective in absorbing heat. If there is secondary combustion between the boiler tubes, which may occur to a considerable extent if there is a laneing action in the gases and may possibly extend entirely through the setting, all of the boiler surface is not effective after combustion is complete, with the result that there is an increase in the temperature of the flue gases over what it would be should the gases be burned within the furnace, and a corresponding loss of efficiency. Again, in some instances there is a loss through combustible elements, such as carbon monoxide, passing off in the flue gases. Another loss that is experienced in coal burning is through the unconsumed fuel in the ashes, often due to poor operation.

Fireman Should Be Provided with Proper Instruments

It is a mistake not to provide proper instruments to guide the firemen. A general impression prevails that test results are one thing and operating results another, and that the operating results necessarily fall considerably below the test results. Operating results do as a rule fall considerably below the test results, but there is no reason why this should be so in the great majority of cases.

It is often assumed that the average flue-gas analysis combined with the percentage of carbon in the ash is a measure of the efficiency of a furnace, and that if these features are known the boiler man should be able to guarantee the boiler efficiency. Such is not the case, as a great deal depends on whether all of the combustion is or is not completed within the furnace chamber. If there is delayed combustion between the tubes of the boiler, it will have an influence on the flue-gas temperature and efficiency, and it can readily be appreciated that if two plants are operating with the same average flue-gas analysis and percentage of carbon in the ash, and in one of the plants there is secondary combustion between the tubes and in the other there is not, the plant where all of the combustion is completed in the furnace will have the highest efficiency.

Often great stress is laid on carrying a high percentage of CO_2 irrespective of the other operating conditions, and in certain instances the firemen are paid bonuses based on the percentage of CO_2. If all the other conditions of operation are watched after, this system will give good results; but if the carrying of a high percentage of CO_2 is made the sole aim of the firemen, there may be wastes in other directions that will counterbalance any gain through minimizing the amount of excess air.

Where a high percentage of CO_2 is carried, it is often found that CO will be present. In some installations it is impossible to carry more than a certain percentage, say 13 per cent., of CO_2 before having a material amount of CO. An analysis with coal firing which indicates 13 per cent. of CO_2 and no CO is more favorable from a heat-loss standpoint than one that gives 15 per cent. of CO_2 and ½ per cent. of CO. As the carrying of a high percentage of CO_2 is apt to lead to secondary combustion between the boiler tubes, thereby involving an additional loss through increasing the temperature of the flue gases, it can readily be seen that it is often a mistake to aim for too high a percentage of CO_2. How high a percentage should be aimed for depends upon the form of furnace and the furnace volume. Ordinarily, with coal it does not pay to exceed about 13½ per cent.

The Hempel type apparatus, where the gases are shaken up with the solutions, is, as a rule, more reliable in indicating the amount of CO than the Orsat, and in accurate work it is well to check the Orsat apparatus against the Hempel.

Clean Feed Water Is Essential

The use of impure feed water is entirely too prevalent. This naturally leads to a loss in efficiency through incrusting the inner part of the heating surface and through making it necessary to blow down the boilers an undue amount. There is an added loss through having to cut out the boilers a large part of the time for cleaning and for replacing leaky tubes. Greater attention is now being given to securing clean feed water, especially in the larger plants. In many instances it pays to install evaporating apparatus for supplying the makeup water. Naturally, this can be done only where surface condensers are used, but where it can be done good results are bound to follow.

A considerable loss in plant efficiency in coal firing often comes through the carrying of banked fires. There is a corresponding loss in burning other fuels, and the operation of a given plant may cause this element to greatly affect the results secured. As an instance, in one particular case where I was active in securing the best results, the economy of an oil-burning plant was raised over 25 per cent. simply through operation and by going over the plant to eliminate heat losses through drips, etc. In oil-burning plants a mistake is often made in keeping the steam pressure as steady as possible by changing the firing conditions one way and the other to such an extent that it is impossible to maintain the best furnace efficiency. The best results are secured by feeding the oil to the burners at a reasonably uniform rate, varying the oil pressure one way and the other slowly to meet the demands of the power, even though this may result in a less steady steam line than would be secured through jumping the oil pressure one way and the other to maintain a practically constant steam pressure. A recording pressure gage placed on the oil line where the steam pressure is maintained at a constant figure will often give illuminating results in indicating a broad band with the oil pressure varying 200 or 300 per cent. one way and the other, whereas for best operation the oil pressure will be represented by a reasonably steady line which will follow in a general way the power requirements. A good guide for efficient operation in running with oil fuel is the amount of superheat obtained, which should be about uniform in all the boilers. If the superheat in a boiler becomes high, it is due either to running the boiler harder than the others or to excess air, either of which conditions should be corrected to obtain the best results.

Another good guide in oil burning is to observe the appearance of the gases as they pass through the setting. If the gases are clear, it indicates excess air, and if too smoky, an insufficient air supply. For the best results there should be a slight haze throughout the gases. The appearance of the gases leaving the stack is also a good guide, as too clear a stack indicates excess air, whereas a smoking stack shows insufficient air in one or more of the boilers, the best conditions being indicated by a slight haze.

It is feasible to set a figure for efficiency higher than

*From a paper before the American Boiler Manufacturers' Association, Buffalo, N. Y.

that which would ordinarily be secured and to pay the operating crew a certain bonus based on the increase in efficiency above this figure. In this connection, Edward N. Trump has said the following:

If you give a bonus to the firemen, you will be sure to have some improvement in efficiency. I have found at least 10 per cent. saving by paying bonuses to the firemen, sometimes by working one shift against the other. Competition encourages them to work harder, to increase the saving.

Mr. Trump has secured record efficiencies in the plants of his company. With boilers of about 300 hp., fitted with economizers, run at from 100 to 120 per cent. of rating, he has secured plant sufficiencies, measured by the monthly operation, of 85 per cent. In his boiler plants with very large units he has obtained a corresponding efficiency of 88 per cent. The load on the boilers in Mr. Trump's plants is nearly uniform and does not vary to the extent that it does in the average electrical-power generating station.

For a long time there were many instances where the use of the older type of waste-heat boilers would not lead to a good return on the investment. Since developing our modern type where the boilers have a considerably higher draft resistance than in the older type and where this draft resistance is overcome through the use of an induced-draft fan, we have installed over 100,000 hp. of such boilers in connection with openhearth furnaces alone, and the steam generated by these boilers represents a saving in the neighborhood of 1,000,000 tons of coal per year. This is only one of the fields where waste-heat boilers may be applied to advantage, and it shows the magnitude of the savings that can be effected.

Furnace Design and Stoker Design

Furnace design cannot be divorced from stoker design when the best obtainable results are aimed for. After designing the stoker, the next feature bearing on economy is the disposition of the surface of the boiler. With a given boiler arrangement, tube spacing, etc., it usually follows that to secure a high heat transfer the draft resistance will be greater than with the same amount of surface arranged and provided with baffles that will give a lower rate of heat transfer. If the arrangement of heating surface and baffles is such as to lead to too high a draft resistance, the capacity developed by the boiler with a given draft may be lower than desired. If the arrangement is such as to give a low draft resistance, the efficiency may be less than it should be. In providing a proper design, one of these features must be balanced against the other and an arrangement provided which will give the best all-round results.

The addition of an economizer will increase the economy, say, 5 to 10 per cent. Now that the price of fuel is increasing everywhere, a greater number of economizers are being installed.

For large plants the efficiency obtainable with a modern steam-boiler and steam-turbine installation is greater than could be secured through gasifying the coal in producers and using the gas in gas engines. A large steam-turbine plant of the best modern design will generate a kilowatt-hour with a heat consumption based on the heat in the fuel of 17,000 B.t.u. per kw.-hr. This as a round figure for plants of the best modern construction with a load factor of, say, 60 per cent. and steam pressures of from 250 to 300 pounds.

By increasing the steam pressure and raising the superheat, the figure can no doubt be reduced to the neighborhood of 15,000 B.t.u. per kilowatt-hour. There is no likelihood of the gas engine displacing the steam turbine for large power generating station work for some time to come.

The Pacific Gas and Electric Co. of San Francisco has purchased all the properties of the Northern California Power Co., at a price said to be $10,000,000. The purchase, it is said in financial circles, is the direct result of coöperative work carried on by the two companies during the war. Properties of the Northern California Power Co. extend from Sacramento to the northern state boundary.

Bearing Metals*

The essential characteristic of all bearing alloys is a structure made up of alternately hard and relatively soft microscopic particles intimately mixed. The function of the hard particles, or bearing crystals, is to support the load and resist the wear. These bearing crystals should not be hard enough to prove distinctly abrasive to the journal surface. General experience shows that an extreme hardness of the bearing crystals is characterized by an excessive wear of the journal. The function of the softer or more readily abraded crystals is that of being plastic and permitting the bearing crystals to adjust themselves to surface requirements of the journal. These softer crystals are also more readily abraded, and therefore wear slighly below the surface of the bearing crystals and thus form upon the bearing surface slight depressions which serve for the retention of the lubricant. However infinitesimal in amount this may seem, nevertheless it is this lubricant that prevents scoring or seizing when the journal is starting up from rest at a time when actual metallic contact between the bearing surfaces exists. The same is equally true under an excessive load. This function of retaining a slight quantity of the lubricant upon the bearing surfaces when metallic contact exists, characterizes a bearing alloy in its truest sense. Therefore a bearing metal may be defined as an alloy that is capable of retaining a lubricant on a bearing surface.

A matter of importance, which seems not to have been considered heretofore, is the fusing temperature of the bearing crystals. From observations made it is evident that under severe conditions where relatively low-fusing bearing crystals exist in a high-fusing alloy, these bearing crystals actually fuse on their surfaces during the process of the "running in" of the bearing. The delta copper-tin crystal (Cu_4Sn) may be cited as a particular example, and in some severe conditions corresponding to automotive worm-drive service the alpha copper-phosphorus crystal (Cu_3P) seems to function in a similar manner. It is doubtful whether these conditions ever obtain in any of the babbitts, since their bearing crystals are the highest-fusing compounds of these alloys.

The study of bearing metals is very incomplete unless these alloys are considered in conjunction with the other corresponding bearing member. The extreme variety of modern steels makes this necessary, since a bearing alloy suited for a soft low-carbon machine-steel journal would not be an economic selection for a high-carbon nickel-chrome heat-treated journal, and a most economic selection for the latter would prove destructive to the former.

It seems exceedingly improbable that laboratory accelerated service tests can ever give general satisfaction, owing to the difficulty of reproducing in a few hours' time the equivalent of many years of service conditions. It is our conviction that much more can be learned from the study of failures, and also in studying old bearings together with their journals, which have given eminently satisfactory service for an exceptionally long period.

Proposed Relay Nomenclature

The Committee on Protective Devices of the American Institute of Electrical Engineers, in making an analysis of the transmission-line protective-relay situation throughout this country, found that the relay nomenclature used by the different operating and manufacturing companies for the various classes of relays was not in harmony. The committee therefore undertook the work of standardizing this nomenclature, and the following has been proposed and was given in a paper, "Transmission-Line Relay Protection," by H. R. Woodrow, D. W. Roper, O. C. Traver and P. MacGahan, presented at the 35th annual convention of the A. I. E. E., June 24 to 27, 1919:

Electric-Protective Relay—An intermediate device by means of which one circuit is indirectly controlled by a

*From report of Sub-Committee on Bearing Metals, Spring meeting, American Society of Mechanical Engineers, Detroit, Mich. June 16-17, 1919.

change in conditions in the same or other circuits. The relay is ordinarily equipped with contacts to open or close an auxiliary circuit.

Directional Relay—Any relay which functions in conformance with direction of power or voltage or current or phase rotation, etc.

Power-Directional Relay—Any relay which functions in conformance with direction of power.

NOTE. This includes both uni-directional relays with single-throw contacts and duo-directional relays with double-throw contacts. The reason this name is preferred to "reverse power" is that the device is frequently used to function under normal direction of power. Furthermore, in some cases the normal condition of the system may permit power to flow in either direction. Relays for use in either alternating or direct-current circuits are to be classed as power-directional relays.

Polarity-Directional Relay—Any relay which functions by reason of a reversal of the normal direction of polarity.

Phase-Rotation Relay—Any relay which functions by reason of a reversal of the normal direction of phase rotation.

Current Relay—Any relay which functions at a predetermined value of the current. These may be either overcurrent relays or undercurrent relays.

Voltage Relay—Any relay which functions at a predetermined value of the voltage. These may be either overvoltage relays or undervoltage relays.

Watt Relay—Any relay which functions at predetermined value of the watts. These may be either overwatt relays or underwatt relays.

Frequency Relay—Any relay which functions at a predetermined value of the frequency. These may be either overfrequency relays or under-frequency relays.

Temperature Relay—Any relay which functions at a predetermined temperature in the apparatus protected.

Open-Phase Relay—Any relay which functions by reason of the opening of one phase of a polyphase circuit.

Differential Relay—Any relay which functions by reason of the difference between two quantities such as current or voltage, etc.

NOTE. This term includes relays heretofore known as "ratio balance relays," "biased" and "percentage differential relays."

Locking Relay—Any relay which renders some other relay or other device inoperative under predetermined values of current or voltage, etc.

Trip-Free Relay—Any relay which prevents holding in an electrically operated device such as a circuit-breaker while an abnormal condition exists on the circuit.

Auxiliary Relay—Any relay which assists another relay in the performance of its function and which operates in response to the opening or closing of its operating circuit.

Signal Relay—An auxiliary relay which operates an audible or a visible signal.

QUALIFYING TERMS AS APPLIED TO RELAYS

Notching—A qualifying term applied to any relay indicating that a number of separate impulses are required to complete operation.

Inverse Time—A qualifying term applied to any relay indicating that there is purposely introduced a delayed action, which delay decreases as the operating force increases.

Definite Time—A qualifying term applied to any relay indicating that there is purposely introduced a delayed action, which delay remains substantially constant regardless of the magnitude of the operating force. (For forces slightly above the minimum operating value the delay may be inverse.)

Instantaneous—A qualifying term applied to any relay indicating that no delayed action is purposely introduced.

Where relays operate in response to changes in more than one condition, all functions should be mentioned.

The Protective Device Committee expresses the desire that the foregoing nomenclature be adopted by all parties so that any particular class of relays will be given a definite name.

Jobs for marine engineers, paying $143.75 a month for third assistants to $287.50 a month for chiefs, with board and quarters free, are actually going begging at Atlantic ports, according to a statement issued by the United States Shipping Board. The situation is acute. Vessels are tied up in many of the larger ports waiting for engineers. There are now 500 engineers in training at special schools, but these are not yet available.

Method of Turning On Steam in Large Lines*

Accidents and consequent losses, both direct and indirect, due to the failure of steam piping and fittings while being cut into service when steam is being turned in, have apparently all been due to expansion strains rather than pressure strains. The expansion strains which caused the damage were usually different from those which were present after the line had been heated to full temperature.

A further analysis discloses the fact that the particular form of expansion causing the trouble has been in most cases due to the presence of air in the steam line at the time steam was being turned on. Air, having approximately twice the density of steam, remains at the bottom of the pipe and prevents the steam from coming in contact with (and thereby expanding) parts of the piping. On a straight run of horizontal piping the result is a tendency to "rainbow" the piping. This has been proved by actual test. The further result of this action is to put a heavy compression strain on the upper half of all joints and fittings and a corresponding tensile strain on the lower half. This trouble is experienced to a greater extent with large than with small piping. This may be due either to the pipe being so small that the air and steam do not remain stratified, or possibly to the great flexibility of the small piping.

The method of turning on steam, which will prevent trouble of this kind, is as follows:

All the drains and air vents on the line are opened. Steam is turned into the line very rapidly, the valve being opened one-fourth to one-half its full opening. This applies not only to low pressure, but to high pressure as well. This procedure results in driving the air out of the line very rapidly and allows the pipe to heat uniformly. To engineers who have been accustomed to "warming up" slowly, or "soaking" the line, this method will no doubt seem dangerous, but the results obtained from close observation and actual test indicate that it is the best that can be followed.

The same phenomena take place in starting up a steam turbine. In the Parsons type of machine where the blade and clearances are small, the "warming up" method of starting is likely to cause blade failures, because when a machine is standing still, the spindle and cylinder "rainbow" in the same direction, but as soon as the spindle revolves one-half a revolution, the top of the spindle (then at the bottom), unless the clearances are large, rubs the bottom of the cylinder. The new method is to open the throttle quickly until the spindle starts to revolve, after which the throttle is almost closed again, allowing the turbine to revolve slowly until the heat is evenly distributed.

The United States Shipping Board Emergency Fleet Corporation has arranged for the sale of its surplus and salvage property. Complete manufacturing plants, entire shipyards, dry docks, ships, complete or half built, and any article down to scrap metal are among the items to be disposed of by public sale. To sell to the market, and not to break the market, is the Government policy in disposal sales to be held by all its departments and branches. Upon the sales list are marine railways, housing and transportation projects, numerous allotments of machinery, equipment and supplies, including wood-working machinery, machine tools and fixtures, electrical machinery, boiler- and forge-shop equipment, marine equipment and accessories, air-compressor equipment, contractors' equipment and supplies, bridge and gantry cranes, steel plates, shapes, and bars, pumping machinery, scrap metals, lumber, deck equipment, galley equipment, hospital and commissary supplies and the like. All sales will be consummated either by open bidding on advertised items or from price lists made up after careful study of existing market conditions and approved by the Sales Review Board.

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*From report of Educational Committee, National District Heating Association.

New Publications

LIQUID FUELS FOR INTERNAL-COMBUSTION ENGINES. By Harold Moore. Published by D. Van Nostrand Co., New York; Cloth; 6 x 8¼ in., 200 pages; illustrated. Price, $5.

The advances made in the design and application of internal-combustion engines makes a book of this kind desirable. The author does not pretend to give an exhaustive explanation of the chemistry of the compounds present in liquid fuels and the reactions involved in their preparation and purification. The book deals chiefly with the procedure necessary for the examination and valuation of liquid fuels for use in engines. The fuels considered are petroleum, shale oil, coal tars, lignite tars, products of the carbonization of wood and peat, animal and vegetable oils, and alcohol. Considerable space is given to fuels for engines fitted with carburetors, vaporizers and atomizers. Calorimetry is the subject of the last chapter. The appendix is made up of much valuable tabular data, as those on spontaneous ignition of various oils and their products, composition of coal tar, calorific properties of various combustibles, limits for downward propagation of flame (air and fuel mixture), oil specifications, a glossary, etc. The volume is well illustrated, though not exceptionally profusely, and it contains considerable tabular matter. Considering these, the price seems high. However, those who feel the need for such a work, will likely be glad to pay it.

Personals

Richard Burroughs, formerly in the engineering department of the Hotel Strand, is now chief engineer of the new Hotel Ambassador, Atlantic City, N. J.

John H. O'Neil, who served with the 38th Engineers in France, has returned to his old position as first assistant engineer with the Blackstone Gas and Electric Co., Pawtucket, R. I.

Miscellaneous News

Shipping Board Needs 1500 Firemen—The United States Shipping Board has announced that it has vacancies for 1500 firemen in the merchant marine. The age limit is from 18 to 35 years; minimum weight 140 lb. The pay of the marine firemen is $75 a month, with board and quarters free.

College Courses in Shipbuilding—Schools of naval architecture and ship construction may soon become important branches of educational institutions of the United States if this nation continues its headway in maritime strength. Fourteen universities and technical colleges have signified their interest in a line of instruction that was decadent almost to the point of extinction when the needs of war presented a demand for ships that could not be denied, and some of them have already established courses in naval architecture, marine engineering and ship construction, while others are planning similar action. The United States Shipping Board Emergency Fleet Corporation, which felt so keenly the lack of technicians in carrying out its shipbuilding program, and had to establish emergency schools for intensive training, is encouraging and fostering plans for the new schools in all institutions capable of expanding their fields of learning. It has furnished to those interested valuable data gained through experience with all phases of the shipbuilding industry in every quarter of the country, and stands ready to give similar aid to all who may apply. Men in closest touch with the situation say that the need for marine architects and engineers will grow as the yards expand and enter the open field of competition in construction for home and foreign account.

Business Items

Plant Engineering and Equipment Co., Inc., has opened branch offices in Kansas City, Mo., 312 Elmhurst Building; Salt Lake City, Utah, 17 Exchange Place, and Charlotte, N. C., 815 Independence Building.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.75@3.25
Philadelphia, gross tons	4.27@4.95	5.95@5.50
New York, gross tons	4.62@5.29	5.29@5.85
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.55

Pocahontas and New River are quoted at $4.70@5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$6.05	$7.90	Pea	4.90	6.65
Egg	5.95	7.80	Buckwheat	3.40	5.15
Stove	6.20	8.05	Rice	2.75	4.50
Chestnut	6.30	8.15	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2.75 @ 2.95	2.95 @ 3.25
Clearfield County	2.50 @ 2.75	2.80 @ 2.95
Reynoldsville	2.50 @ 2.75	2.75 @ 2.95
Quemahoning	2.65 @ 2.85	2.95 @ 3.10
Somerset County (best grades)	2.50 @ 2.75	2.95 @ 3.10
Somerset County (poorer grades)	2.00 @ 2.35	2.50 @ 2.75
Western Maryland	2.25 @ 2.50	2.50 @ 2.75
Fairmont	2.00 @ 2.25	2.35 @ 2.50
Latrobe	2.10 @ 2.25	2.25 @ 2.40
Greensburg	2.25 @ 2.35	2.35 @ 2.60
Westmoreland	2.60 @ 2.75	2.60 @ 2.75
Westmoreland run-of-mine	2.35 @ 2.60	2.35 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	6.05	7.90	Rice	2.75	3.65
Stove	6.30	8.15	Boiler	2.50	3.50
Nut	6.40	8.25	Barley	2.25	3.15
Pea	5.00	6.60	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@ 2.50	3.00
Screenings	1.85@ 2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.95@$4.60
Corona	3.50
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County	Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	.....
Williamson County		
Prepared sizes, lump, egg, nut	$2.55	$2.55	$2.00@2.25
Mine-run	2.35	2.20	1.60@1.75
Screenings	2.20	2.05	1.15@1.30
3-in. lump	....	2.30	.....
2-in. lump	....	....	1.75@1.90

Williamson-Franklin rate to St Louis is $1.07; other rates 92½c.

New Construction

PROPOSED WORK

Mass., New Bedford—The National Sponge Silk Co., c/o Lockwood-Greene Co., Arch., 101 Park Ave., New York City, will install a steam heating system in the 4-story, 120 x 400 ft. factory which it plans to build. Total estimated cost, $750,000.

N. Y., Brooklyn—The Long Island Amusement Co., Garden Theatre, Jamaica, will install a steam heating system in the 1 story, 130 x 140 ft. theatre which it plans to build on Fulton St., near Church Ave., here. Total estimated cost, $400,000. G. Mausert, Pres., R. T. Short, 370 Macon St., Arch.

N. Y., Brooklyn—The Gibbons Co., 316 Columbia St., will install a steam heating system in the 5 story, 125 x 175 ft. office building which it plans to build on Columbia St. and Hamilton Ave. Total estimated cost, $250,000.

N. Y., Brooklyn—Mason Au Mangenheimer, 22 Henry St., will install a steam heating system in the 8 story, 60 x 100 ft. factory which it plans to build at 24 Henry St. Total estimated cost, $150,000. Ebling & Magnerson, 52 Vanderbilt St., New York City, Arch.

N. Y., Brooklyn—C. Hutwelke, 655 5th Ave., will install a steam heating system in the 5 story, 63 x 100 ft. packing house which he plans to build on Hall St., near Flushing Ave. Total estimated cost, $100,000. E. F. Seelye, 101 Park Ave., New York City, Engr.

N. Y., Long Island City—L. Gold, 44 Court St., Brooklyn, will install a steam heating system in the 2 story, 75 x 190 ft. garage which he plans to build on William St., near North James St. Total estimated cost, $110,000. F. S. Parker, 44 Court St., Brooklyn, Engr.

N. Y., Long Island City—J. Simons Co., 350 Broadway, New York City, will install a steam heating system in the blacksmith shop and garage which it plans to build on Nelson Ave. Total estimated cost, $100,000. Westinghouse, Church & Kerr, 37 Wall St., New York City, Engr.

N. Y., New York—W. J. Wilgin, 165 Broadway, will install a steam heating system in the 1 story, 75 x 100 ft. garage which he plans to build at 149th St. and Park Ave. Total estimated cost, $155,000. A. Fellheimer, 7 East 42nd St., Arch.

N. Y., New York—Street & Smith, 161 West 15th St., will install a steam heating system in the 7 story, 50 x 100 ft. addition which it plans to build to its publishing house. Total estimated cost, $125,000. H. O. Chapman, 334 5th Ave., Arch.

N. Y., New York—A. Lewisohn, 61 Broadway, will install a steam heating system in the 1 story, 83 x 176 ft. theatre which it plans to build at 4023 Broadway. Total estimated cost, $120,000. G. M. Pollard, 347 5th Ave., Engr.

N. Y., New York—The C. Hensel Realty Co., 3879 10th Ave., will install a steam heating system in the 2 story theatre, store and office building which it plans to construct on Dyckman St., between Nagle and Post Ave. Total estimated cost, $300,000. Moore & Landseidel, 148th St. and 3rd Ave., Arch.

N. Y., New York—The Butterick Publishing Co., Spring and Varick St., will install a steam heating system in the 9 story addition which it will construct to its loft building. Total estimated cost, $1,200,000. Ballinger & Perrott, 47 West 34th St., Archt. and Engr.

N. Y., New York—The Metropolitan Life Insurance Co., Madison Ave., will install a steam heating system in the 16 story, 75 x 150 ft. auditorium and office building which it plans to build at 11-15 Madison Ave. Total estimated cost, $800,000. D. E. Ward, 1 Madison Ave., Engr.

N. Y., New York—G. Backer Construction Co., 11 East 55th St., will install a steam heating system in the 1 story, 50 x 100 ft. mercantile building which it plans to build at 16-18 West 36th St. Total estimated cost, $225,000. Sommerfield & Steckler, 31 Union Sq., Arch.

N. Y., New York—The Fifth Ave. Baptist Church, 8 West 46th St., will install a steam heating system in the 3 story, 80 x 98 ft., church which it plans to build at 64th St. and Park Ave. H. C. Pelton & Allen & Collens, 35 West 39th St., Engr.

N. Y., New York—The Krims Realty Co., 426 West 14th St., will install a steam heating system in the 3 story, 25 x 100 ft. store and office building which it plans to build at 143 West 33rd St. Total estimated cost, $100,000. M. Krim, Pres. M. S. Schwartz, 309 Bway., Arch.

N. Y., Yonkers—The Federal Sugar Refining Co., 91 Wall St., New York City, will install a steam heating system in the warehouse which it plans to build here. Total estimated cost, $200,000. Westinghouse, Church, Kerr & Co., 37 Wall St., New York City, Engr.

N. J., New Brunswick—The Victory Amusement Corp. will install a steam heating system in the 100 x 100 ft. theatre which it plans to build on Albany and Washington St. Total estimated cost, $300,000. J. H. Scheier, 25 West 42nd St., New York City, Arch.

Penn., Grove City—The Municipal Electric Power Co. plans to build a new power plant and equip same with machinery. Estimated cost, $75,000.

Penn., Philadelphia—The Beth Salem congregation, 224 Market St., will install a heating system in the 3 story, 100 x 125 ft. synagogue which it plans to build. Total estimated cost, $100,000. Fieldstein & Rothchilds, 1238 Chestnut St., Arch.

Penn., Philadelphia—The Vigogne Mills, Unity and Oakland St., will install a steam heating system, boilers and engines, in the 3 story, 65 x 250 ft. mill which it plans to build. M. Ward Easby, 1420 Chestnut St., Arch.

Penn., Philadelphia—J. C. Kahn, Morris Bldg., will install a steam heating system in the 7 story, 101 x 150 ft. loft building which he plans to build. Total estimated cost, $300,000. Le Roy B. Rothchild, 1225 Morris Bldg., Arch.

Md., Baltimore—W. Schluderberg & Son, 4th and Bank St., will install a steam heating system and refrigerators in the 4 or 5 story meat packing plant which they plan to build on East Baltimore St., between 5th and 7th St. Total estimated cost, $250,000. C. B. Comstock, 110 West 40th St., New York City, Engr.

Md., Baltimore—St. Mary's Industrial School, Wilkins Ave., will install a vapor heating system in the 4 story, 63 x 113 ft. dormitory and swimming pool which it plans to build. Total estimated cost, $200,000. H. I. Kavanaugh, 913 North Charles St., Arch.

Md., Baltimore—The Luther Memorial Lutheran Church, 345 Ilchester Ave., will install a steam heating system in the 2 story, 75 x 150 ft. church which it plans to build on Guildford Terrace and University Parkway. Total estimated cost, $100,000. John Freund, 11 East Lexington St., Arch.

S. C., Clinton—The Board of Regents of the State Hospital for Insane, Columbia, will install two steam heating plants in connection with the construction of two 1 and 2 story dormitories for the School for Feeble Minded, about ½ mi. from here. R. G. Scarborough, Chn. G. E. Lafaye, 1003 Loan & Exchange Bank Bldg., Columbia, Arch.

S. C., York—The School Board will install a heating plant and modern ventilating system in the 2 story, 100 x 150 ft. high school which it plans to build. Total estimated cost $100,000. S. McDow, Chn. C. Wilson, 808 Palmetto Bldg., Columbia, Arch.

La., New Orleans—The Charity Hospital, Tulane Ave., plans to build a 2 story power house. Estimated cost, $90,000. A. W. Lewin, Weis Bldg., Engr.

Ohio, Cleveland—The Arjo Realty Co., 214 Williamson Bldg., plans to build an addition to its factory at 6545 Euclid Ave. A steam heating system will be installed in same. Total estimated cost, $250,000.

Ohio, Cleveland—The Cuyahoga County Memorial Association, Court House, will install a steam heating system in the 5 story, 150 x 200 ft. hospital which it plans to build on West 4th St. and Fairchild Ave. Total estimated cost, $300,000. W. S. Lougee, 500 Marshall Bldg., Arch.

Ohio, Cleveland—The Euclid Chester Co., Guardian Bldg., will install a steam heating system in the 2 story, 100 x 112 ft. warehouse which it plans to build at 2900 Chester Ave. Total estimated cost, $100,000.

Ohio, Cleveland—The Pilgrim congregation, West 14th St. and Starkweather Ave., will install a steam heating system in the 5 story, 100 x 200 ft. clubhouse which it plans to build. Total estimated cost, $100,000. D. F. Bradley, pastor.

Ohio, Cleveland—The Sixth City Realty Co., Guardian Bldg., will install a steam heating system in the 167 x 370 ft. garage which it plans to build on East 6th St. and St. Clair Ave. Total estimated cost, $1,300,000.

Ohio, Cleveland—The United Motors Service Co., East 40th St. and Prospect Ave., will install a steam heating system in the 2 story, 100 x 200 ft. sales and service building which it plans to build. Total estimated cost, $200,000.

Ohio, Piqua—The J. J. Wernette Engineering Co., 441 Houseman Bldg., Grand Rapids, is receiving bids for a 475 k.v.a., 80 per cent power factor, 240 volt, 3 phase, 60 cycle generator, for the French Oil Mill Machinery Co., here.

Mich., Detroit—The Public Welfare Commission, City Service Bldg., will install a steam heating system in the 4 story, 50 x 87 x 216 ft. hospital which it plans to build on St. Antoine and Macomb St. Total estimated cost, $420,000. J. Scott & Co., 2326 Dime Bank Bldg., Arch.

Mich., Flint—St. Mathew's Parish will install a steam heating system in the 1 story church which it plans to build on Beach St. Total estimated cost, $150,000. Van Leyden, Schilling & Keough, 1115 Union Trust Bldg., Detroit, Engr.

Mich., Hamtramck (Detroit P. O.)—The Board of Education, 50 Broadway, Detroit, will install a steam heating system in the 2 story, 127 x 104 ft. school which it plans to build on Carpenter and McDougall Ave. Malcolmson & Higginbotham, 404 Moffat Bldg., Detroit, Arch.

Mich., Wahjameja—The Michigan Colony for Epileptics will install a steam heating system, including a pump and ash hoist, in the 1 story, 43 x 265 ft. hospital which it plans to build. E. R. Dunlop, 709 Hammond Bldg., Detroit, Arch.

Wis., Sheboygan—The Commercial Engraving Co., 101 North 8th St., will install a steam heating system in the 3 story, 60 x 170 ft. engraving and printing plant which it plans to build on 8th St. Estimated cost, $150,000.

Kan., Salina—The Planters Hotel Co. will install a steam heating system in the 4 story, 100 x 120 ft. hotel which it plans to build. Total estimated cost, $150,000. C. W. Shaver, Arch.

Kan., Stockton—Rooks County will install a steam heating system in the 3 story, 80 x 100 ft. court house which it plans to build. Total estimated cost, $200,000. F. C. Squires, Topeka, Kan., Arch.

Minn., Duluth—The West Duluth Y. M. C. A., North Central Ave., will install a steam heating system in the 3 story, 80 x 135 ft. building which it plans to construct. Total estimated cost, $100,000. Zirman & Jenssen, Exchange Bldg., Engr.

Mo., Kansas City—The National Cloak & Suit Co., 207 West 24th St., New York City, N. Y., will install a steam heating plant in the 12 story factory which it plans to build here. Total estimated cost, $2,500,000. N. M. Dunning, 310 South Wabash Ave., Chicago, Ill., Engr.

Okla., Oklahoma—The Tradesman's State Bank, 105 West Main St., will install washed air, heating and ventilating systems in the 10 story, 60 x 90 ft. bank which it plans to build on Main and Broad St. Total estimated cost, $300,000. Hawk & Parr, 501 Security Bldg., Arch.

Idaho, Boise—Tourtellota-Hummell Co., Overland Bldg., Boise, will install a steam heating system in the 4 story, 100 x 122 ft. Y. M. C. A. building which it plans to construct. Total estimated cost, $125,000.

Cal., Eagle Rock—Bids will be received until July 21, by B. B. Martsoff, City Clk., for furnishing a deep well turbine pump of centrifugal runner type, to have a capacity of 350 gal. per minute on 125 ft. lift.

Que., Montreal—The Provincial Government, Quebec City, will install a steam heating system in the 5 story, 100 x 150 ft. court house which it plans to build on Notre Dame St., E., here. Total estimated cost, $100,000. Dept. of Pub. Wks., Quebec City, Engr.

Que., Montreal—Bids will be received until July 21, by L. R. Thompson, Secy. and Engr., Lignite Utilization Board of Canada, 80 St. Francis Xavier St., for furnishing three, 125 hp. horizontal return tubular boilers with fittings for 150 lb. pressure, suitable for suspension setting; 1 steam driven boiler feed pump, suitable for above boilers, two 200 k.v.a., 550 v., 3 phase, 60 cycle, gasoline or oil driven emergency lighting set; 1 standard underwriters' steam fire pump, having a capacity of 1000 gal. per minute, 150 lb. steam pressure.

Ont., Walker—The General Motors Corp., Boyer Bldg., Detroit, Mich., is in the market for about 425 motors, including 100 five hp. and 150 three hp. motors, for its plant here.

CONTRACTS AWARDED

N. Y., New York—B. S. Moss, 729 7th Ave., has awarded the contract for the construction of a 2 story, 125 x 150 ft. theatre which he plans to build at 161st St. and Prospect Ave., to the Fleischman Construction Co., 531 7th Ave. A steam heating system will be installed in same. Total estimated cost, $600,000.

Ohio, Cleveland—The city has awarded the contract for installing a steam heating system in the 2 story, 70 x 76 ft. bathhouse and gymnasium which it plans to build at East 26th and Central St., to the Chafer Co., 431 Champlain Ave.

Ohio, Cleveland—The Grabler Manufacturing Co., 6565 Broadway Ave., has awarded the contract for the construction of a 4 story, 90 x 100 ft. addition to its factory, to S. W. Emerson Co., 1900 Euclid Ave. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ohio, Cleveland—The McKinney Steel Co., 4002 Dille Rd., will build a 2 story, 32 x 50 ft. pump house by day labor. Estimated cost, $10,000.

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